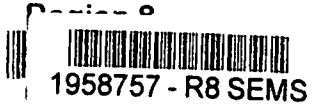
[redacted] TMC Employee Grievances File
[redacted]ORGAN, DANIEL
[redacted] Privileged-PA

[redacted] Privileged-PA



MEMORANDUM

Ref: 1182/900212.MWQ

TO: A. Brown AB

FROM: S. Dyke 2/5/90

RE: Madison Aquifer Water Quality

DATE: February 12, 1990

Per your request, attached is information that can be used to analyze the water quality in the Madison Aquifer. The Madison Aquifer may be used to supply water for reclamation and process purposes at Brohm Mining's Gilt Edge Project, South Dakota.

The data utilized is supplied by Earl A. Greene, a hydrologist with the U.S.G.S. in South Dakota (605-394-1780). The data was originally compiled for use in a U.S.G.S. report entitled "*Geohydrology and Water Quality of the Inyan Kara, Minnelusa, and Madison Aquifers of the Northern Black Hills, South Dakota and Wyoming, and Bear Lodge Mountains, Wyoming*", authored by Kyllonen and Peter.

The data sent to ABC has been entered into a Lotus spreadsheet (900201MQ.WK1), checked, and re-arranged. The resulting database is presented as an attachment to this memo. Note that sampling locations have been assigned an ABC # (i.e. M1 for Madison #1), in addition to the original 15 digit latitude/longitude description. This renumbering will facilitate analysis and compilation of the data.

The reworked database also includes entries for the X and Y coordinate of each sampling point. These values correlate with the grid found on the Deadwood South, S.D., U.S.G.S. topo map. To obtain these values, the latitude and longitude were convèrted to decimal degrees and then substituted in a conversion formula. The conversion calculations may be found in the Lotus spreadsheet 900131XY.WK1. For a further check, the hand calculations used to determine the appropriate factors for the conversion equations are found in the ABC Project 1182 files.

The X and Y coordinates of each sampling station were then plotted in AutoCad and labeled with the new M#. For a perspective on the distance between sampling points, Brohm's proposed pit and the town of Deadwood S.D. are also shown. Unfortunately, none of the sampling locations are in close proximity to the Brohm project. However, this data *can* be used to analyze regional characteristics

of the Madison Aquifer water quality.

Figure 1 shows the water quality sampling locations, in addition to sampling date(s) from that site included in the database. From the ensuing concentration maps, (Figures 2-8), data correlations do not appear to be sample time dependent. Most sampling occured in the late 1970's and early 1980's.

From the following data and figures, it is clear that water quality to the north is of considerably poorer quality than it is to the south. As Kyllonen and Peter summarize "*The prinicipal deterrents of the use of water from the Madison aquifer are fluoride, gross alpha radiaation, sulfate, and hardness, in the northern part of the study area. In the southern one-half of the study area, water quality generally is suitable for public water systems and irrigation, though the water is hard to very hard.*".

Because the Madison is primarily limestone, the groundwater in contact with the Madison tends to be quite hard. Figure 2 displays hardness values from various points in the Madison. Again, values to the north are considerably higher (nearly 5 times higher), than they are to the south, near the Brohm pit. However, hard water is defined by Hem as greater than 120 mg/l CaCO3, which would define all samples, barring M5, as being very hard water. This water would probably need to be softened before any domestic use.

Field pH values range from 7.0 to 8.0, and are presented in Figure 3. Just to the north and east of the Gilt Edge Project, pH values are in the low to mid 7's. Based on the pH values, alkalinity should be present as HCO3, bicarbonate. Figure 4 is a plot of bicarbonate concentrations, which are generally quite high (200-300 mg/l as HCO3). Concentrations above 100 mg/l are considered to contain significant buffering capacity. Concentrations above 200 and 300 mg/l HCO3 have enormous buffering capacity (verbal communication, M. Logsdon). The water samples with the highest bufferring capacity are from points closest to the Brohm project. This water is also of considerably better quality overall than the lower bicarbonate concentration water to the north.

Specific conductance, a gross water quality parameter, is generally low in the southern part of the area (400 - 900 us/cm). However, as Figure 5 displays, samples from M21, M17, and M13 are measured at greater than 1500 us/cm.

Dissolved copper concentrations in the Madison as shown on Figure 6 are very low and mostly below detection limits. An anomoulous value of 130 ug/l was found to be in a sample from M3, west of the proposed pit. The text, Geochemistry in Mineral Exploration, states that at normal pH ranges, Cu has limited solubility. That would appear to be true for the Madison aquifer. The secondary

drinking water standard for copper is 1000 ug/l.

Zinc concentrations are also very low, as Figure 7 displays. The secondary drinking water standard for zinc is 5 mg/l, or 5000 ug/l. The highest concentration reported is for M21 to the far north, at 840 ug/l dissolved zinc. According to Hem 1983, "*In some of the igneous-rock minerals, zinc may replace iron or magnesium, and it is commonly present in carbonate rocks.*"

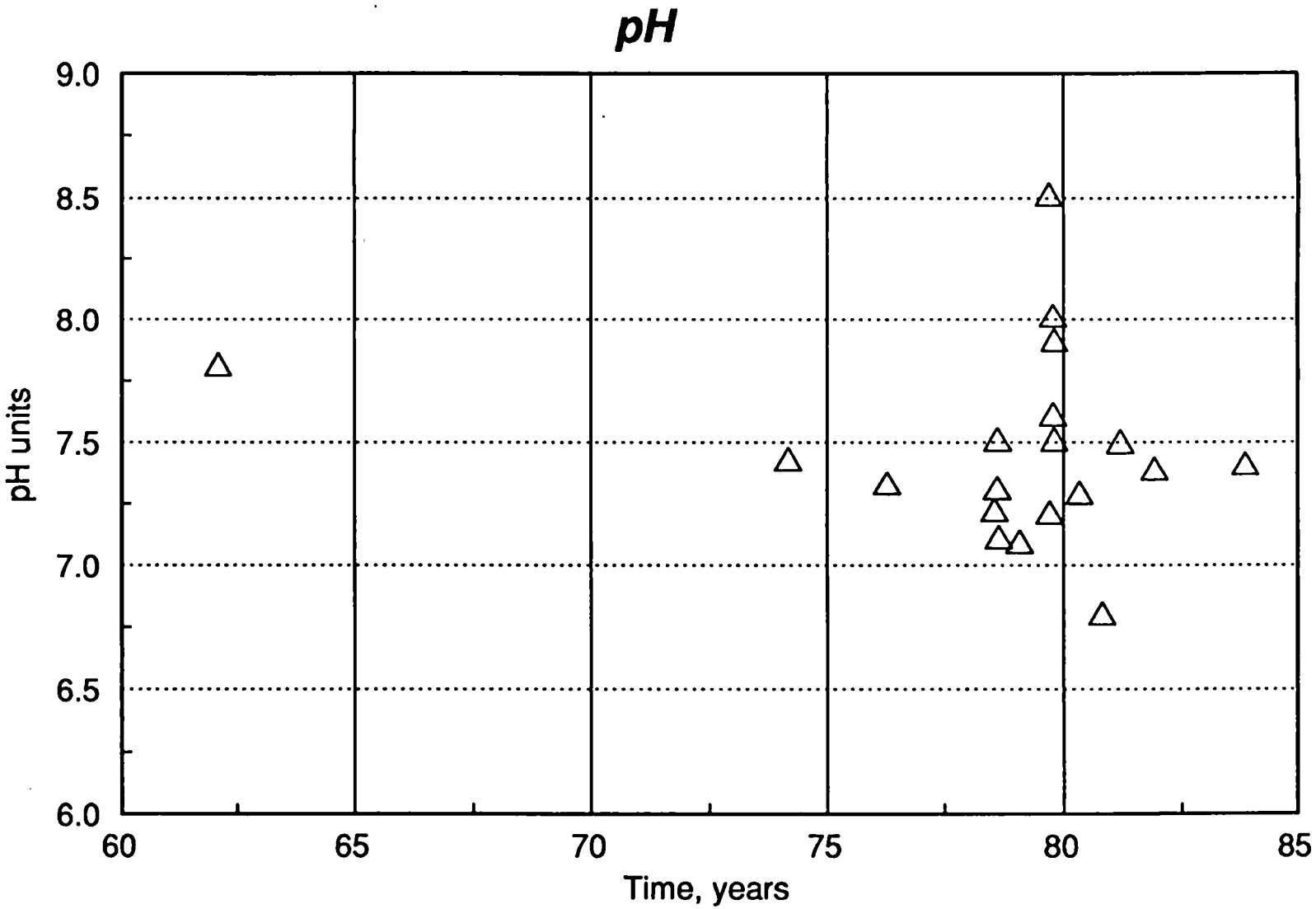
Sulfate values range from below detection to 1600 mg/l. The secondary drinking water standard is set at 250 mg/l. Figure 8 presents the sulfate concentrations. Although constrained by limited data, there seems to be a general correlation between the higher sulfate and the higher copper and zinc concentrations. These areas could perhaps be old mining sites with acid mine drainage problems, or possibly the site of some concentrated surface water discharges to the groundwater system.

Also attached to this memo are rough plots of concentrations of various constituents with time. The data for these plots are found in the database. Some average values from the Madison groundwater are given below:

pH	7.4
HCO3	260 mg/l
Hardness	400 mg/l as CaCo3
Ion Balance	+1%

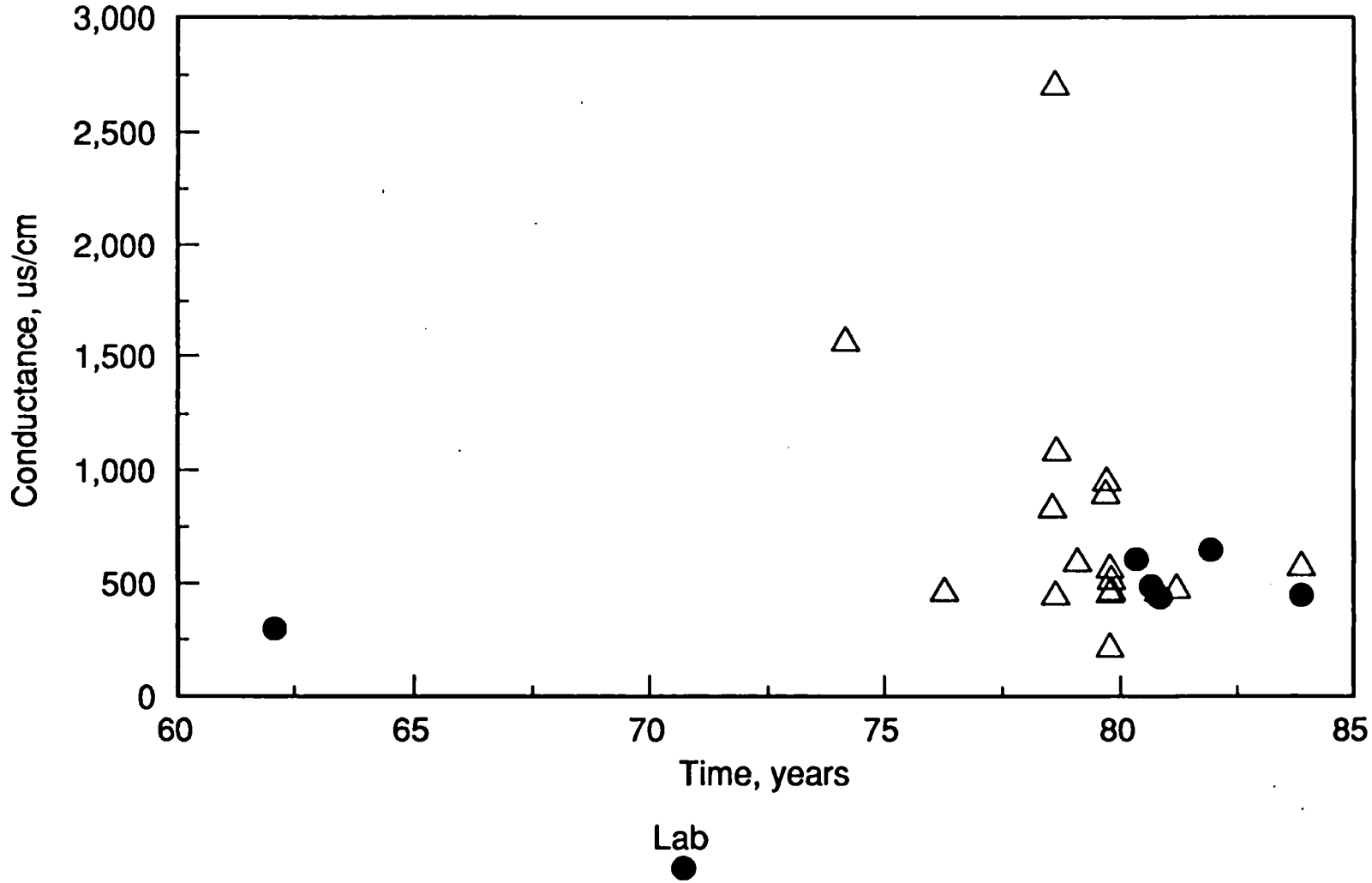
The ion balances for each sample were calculated and are presented in the accompanying database. In general, they are quite good (below 1%), when data is sufficient. However, a number of parameters are not reported for many of the samples, resulting in a poor ion balance due to lack of data.

Madison Aquifer Water Chemistry



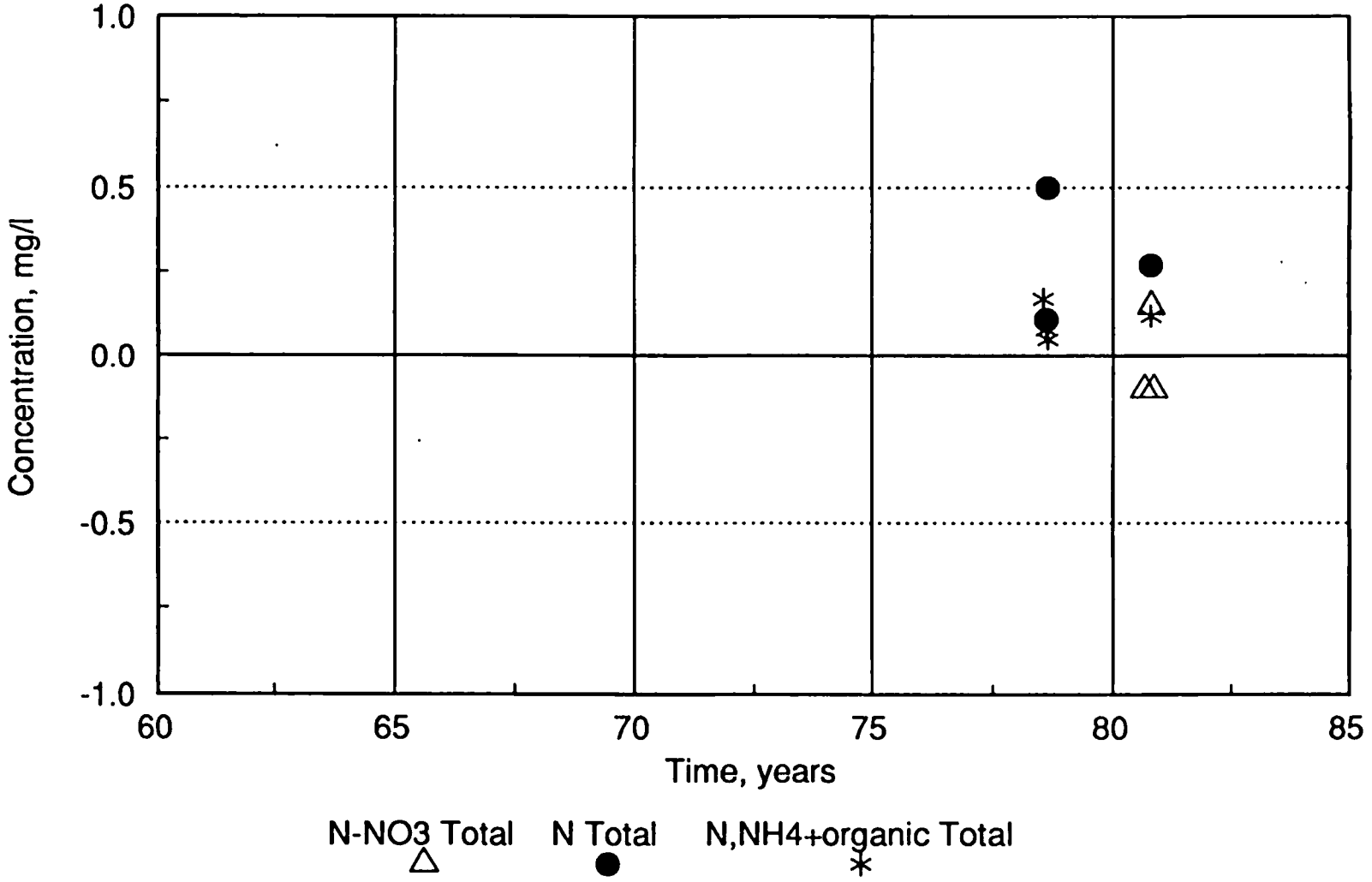
Madison Aquifer Water Quality

Specific Conductance



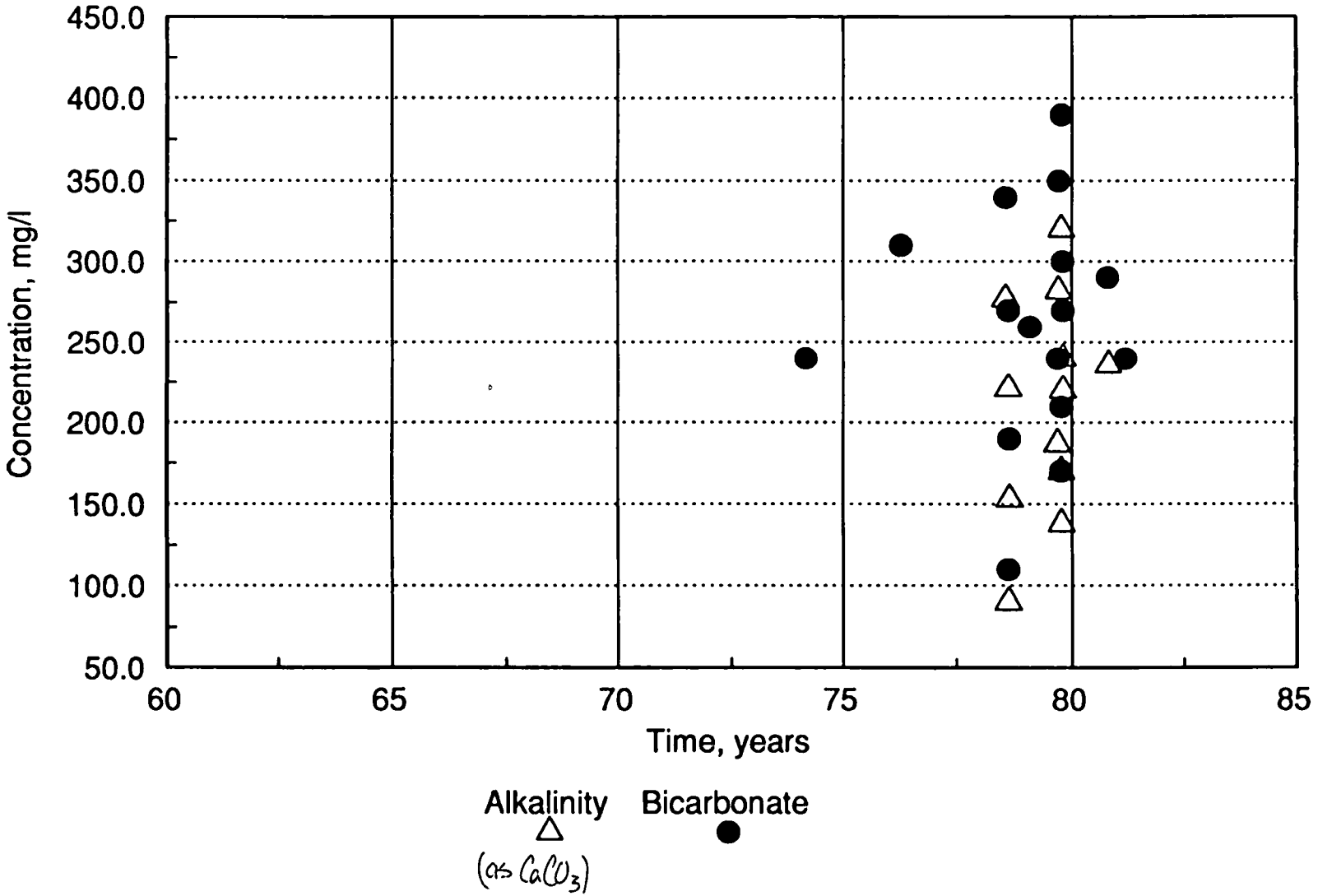
Madison Aquifer Water Quality

All Parameters in mg/l as N



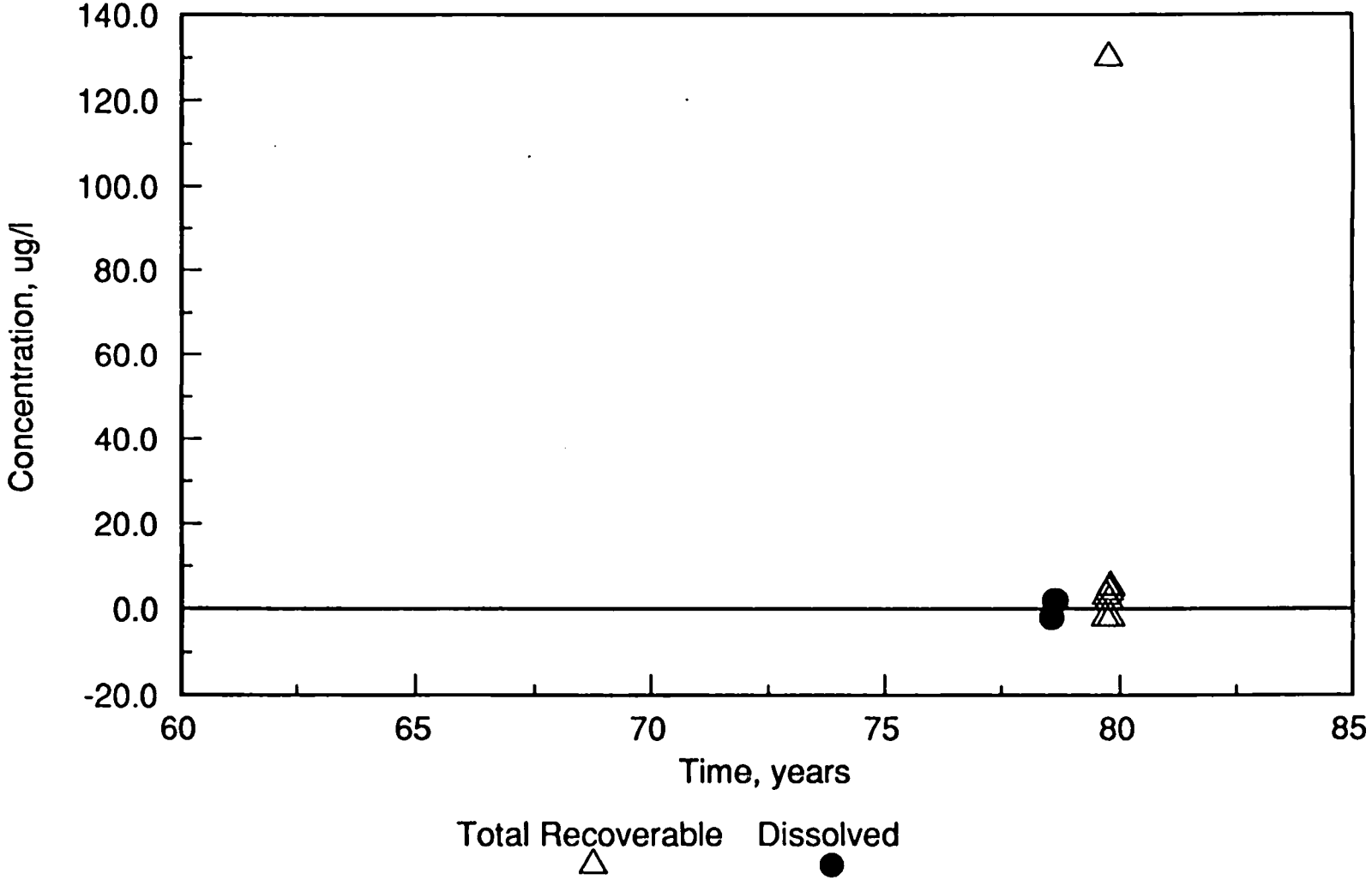
Madison Aquifer Water Quality

Field Parameters



Madison Aquifer Water Quality

Copper



Madison Aquifer Water Quality

Zinc

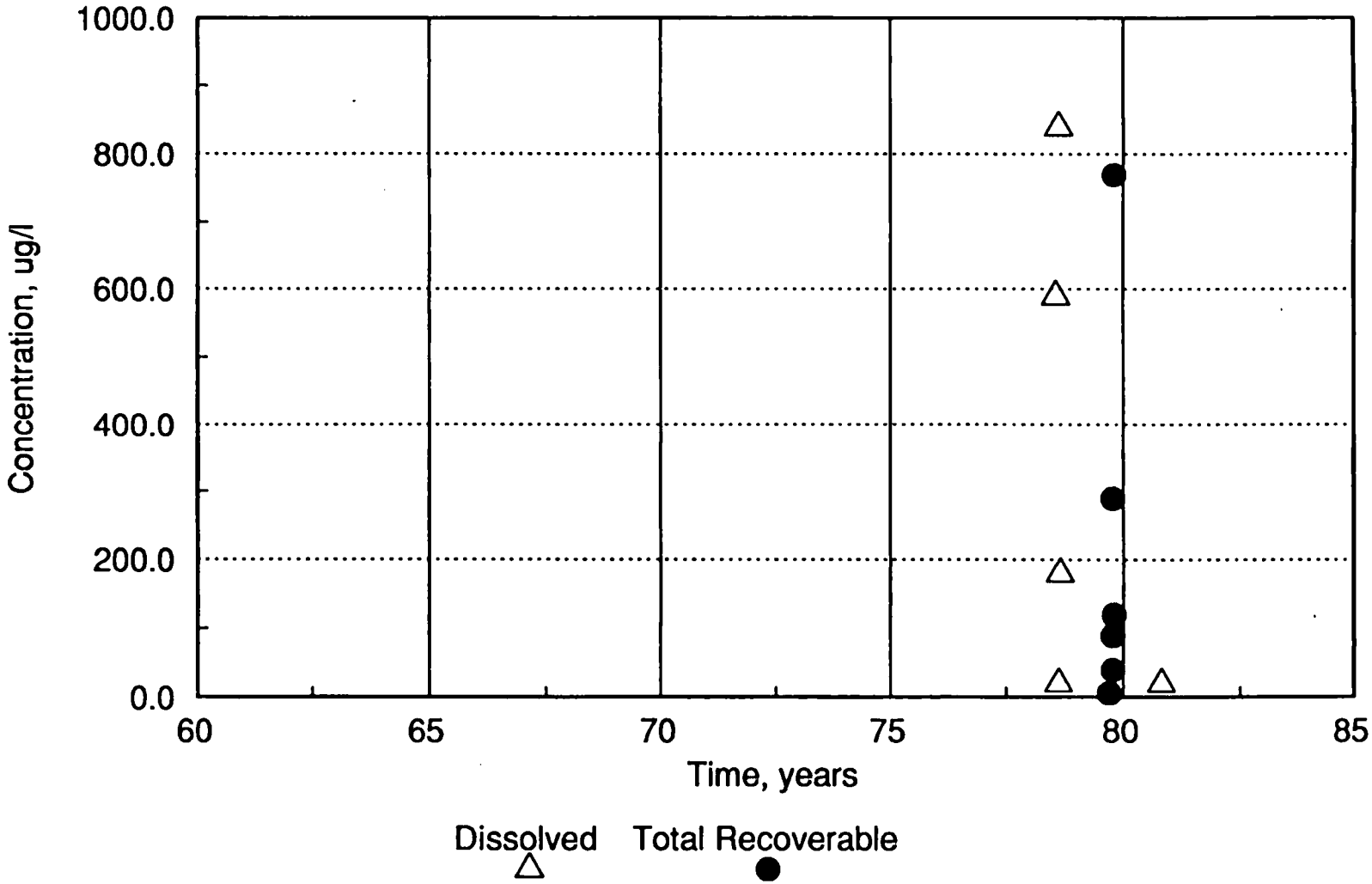
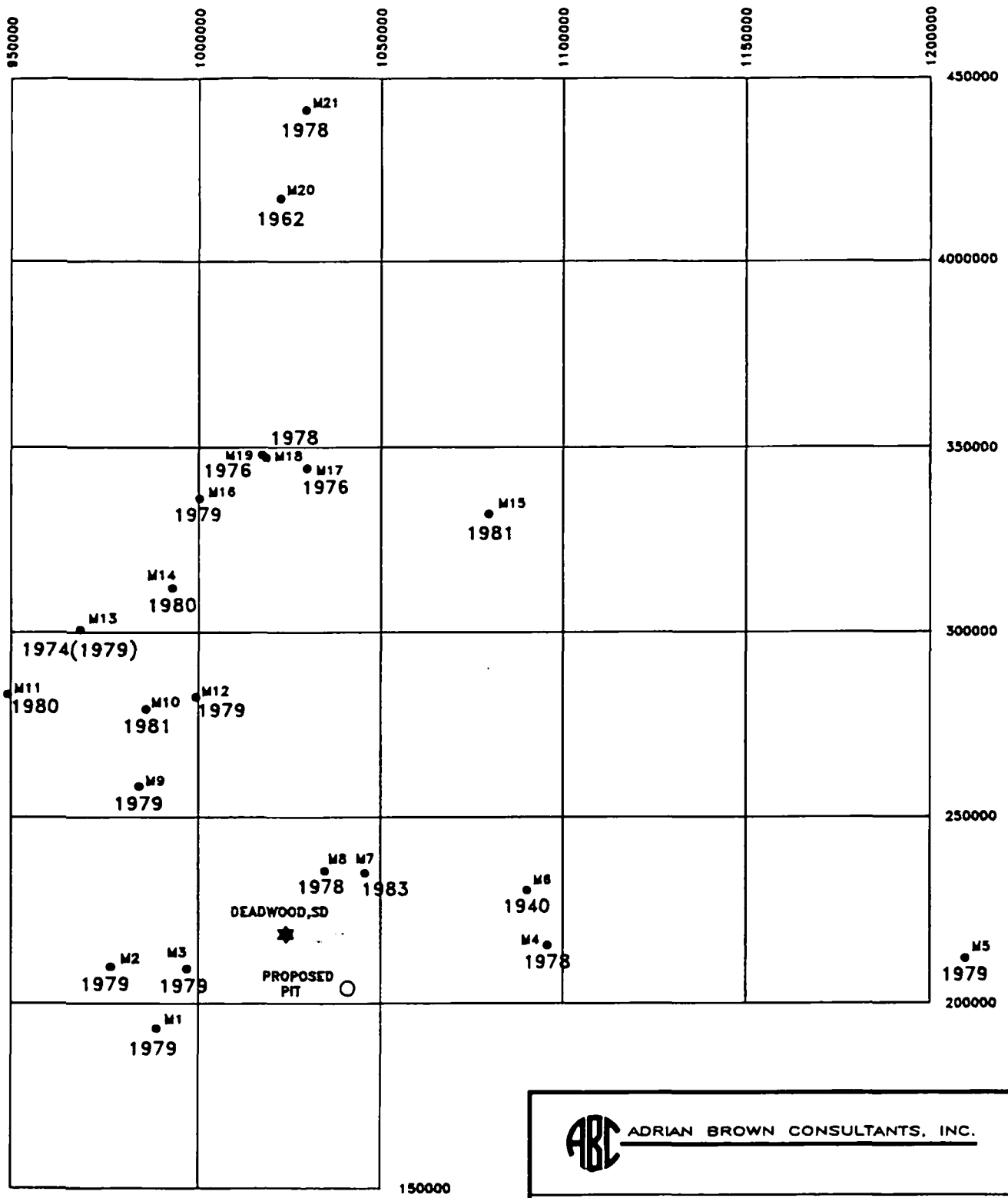


Table A-4 - Expected final pit water quality

SPECIES	UNIT	<----GROUNDWATER----> ACID (1)	NATURAL (2)	FINAL PIT WATER	Inferred Water Quality of the Madison in the vicinity of the pit
TDS	mg/l	1567	232	432	-
Conductivity	umho/cm	1780	360	572	450
pH	units	2.36	7.11	7.00	7.4
Hardness ($CaCO_3$)	mg/l	405	173	208	250
Carbonate	mg/l	0	0	0	0
Bicarbonate	mg/l	0	124	20	250
Chloride	mg/l	7.5	5.0	6	<10
Sulfate	mg/l	1020	60	200	10
Calcium	mg/l	109	56	64	60
Magnesium	mg/l	32	8	11	20
Potassium	mg/l	5	1	2	1
Sodium	mg/l	13	4	5	2
Nitrogen-Tot	mg/l	1.10	0.15	.3	
Phosphorus-Tot	mg/l	0.049	0.027	.03	
Cyanide-Tot	mg/l	<0.01	<0.01	<0.01	
Aluminum	mg/l	76	0.99	1*	
Arsenic	mg/l	0.0091	0.013	.001	
Cadmium	mg/l	0.041	0.0013	.002	
Chromium	mg/l	0.29	0.032	0.033	
Copper	mg/l	4.99	0.02	.02	
Gold	mg/l	0.009	<0.005	<0.005	
Iron	mg/l	12.0	3.9	1*	
Lead	mg/l	0.043	0.016	0.02	
Manganese	mg/l	6.49	0.07	0.5	
Mercury	mg/l	<0.0002	0.0002	<0.0002	
Nickel	mg/l	1.25	0.060	.06	
Selenium	mg/l	0.010	0.011	0.01	
Silver	mg/l	0.0118	0.0075	0.01	
Zinc	mg/l	3.14	0.04	0.1	

(1) GW-7 well, on November 16, 1985 (EnecoTech, 1988).
(2) GW-1 well, on November 16, 1985 (EnecoTech, 1988).
* Expected dissolved values



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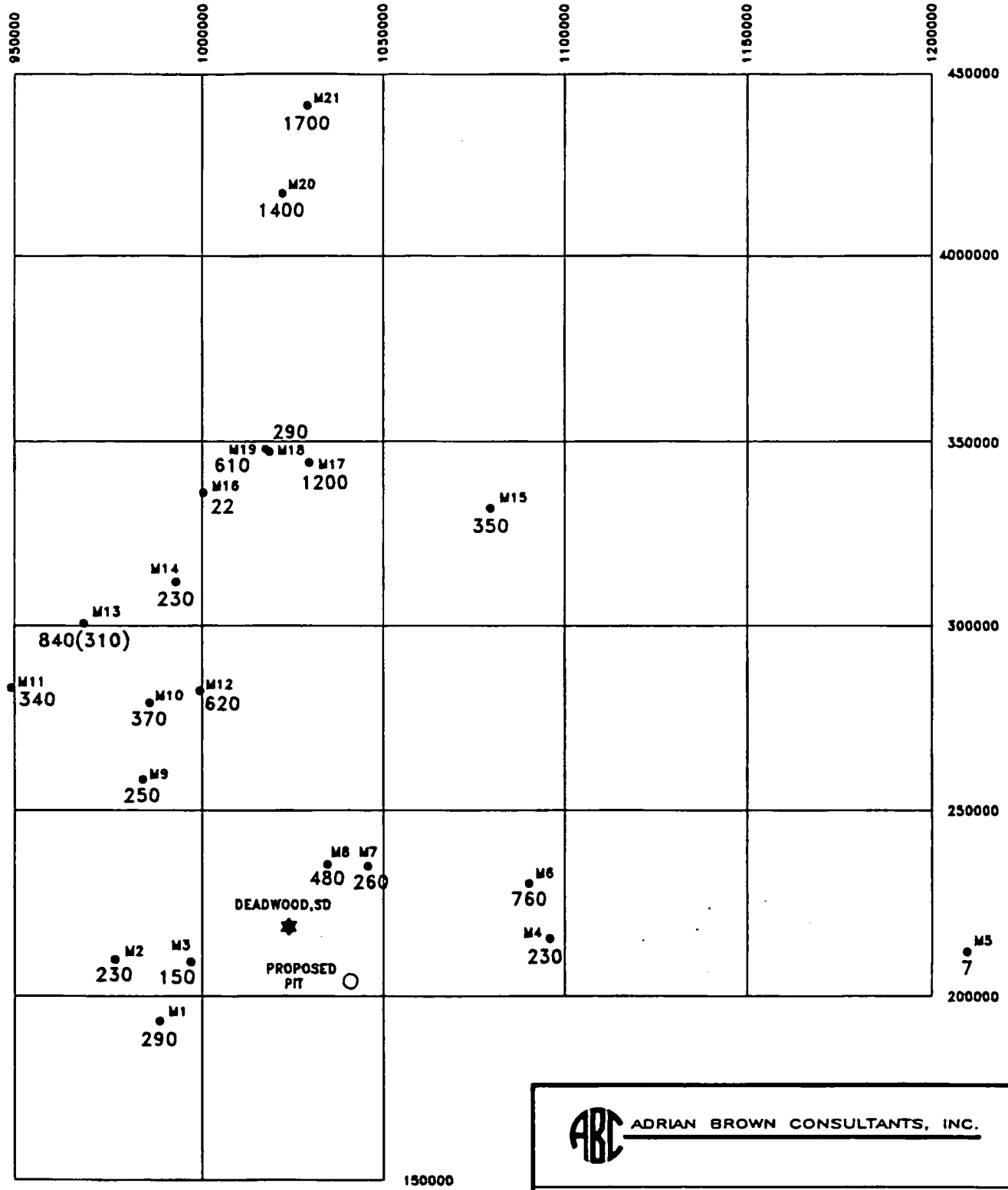
WATER QUALITY SAMPLING DATA

Figure 1



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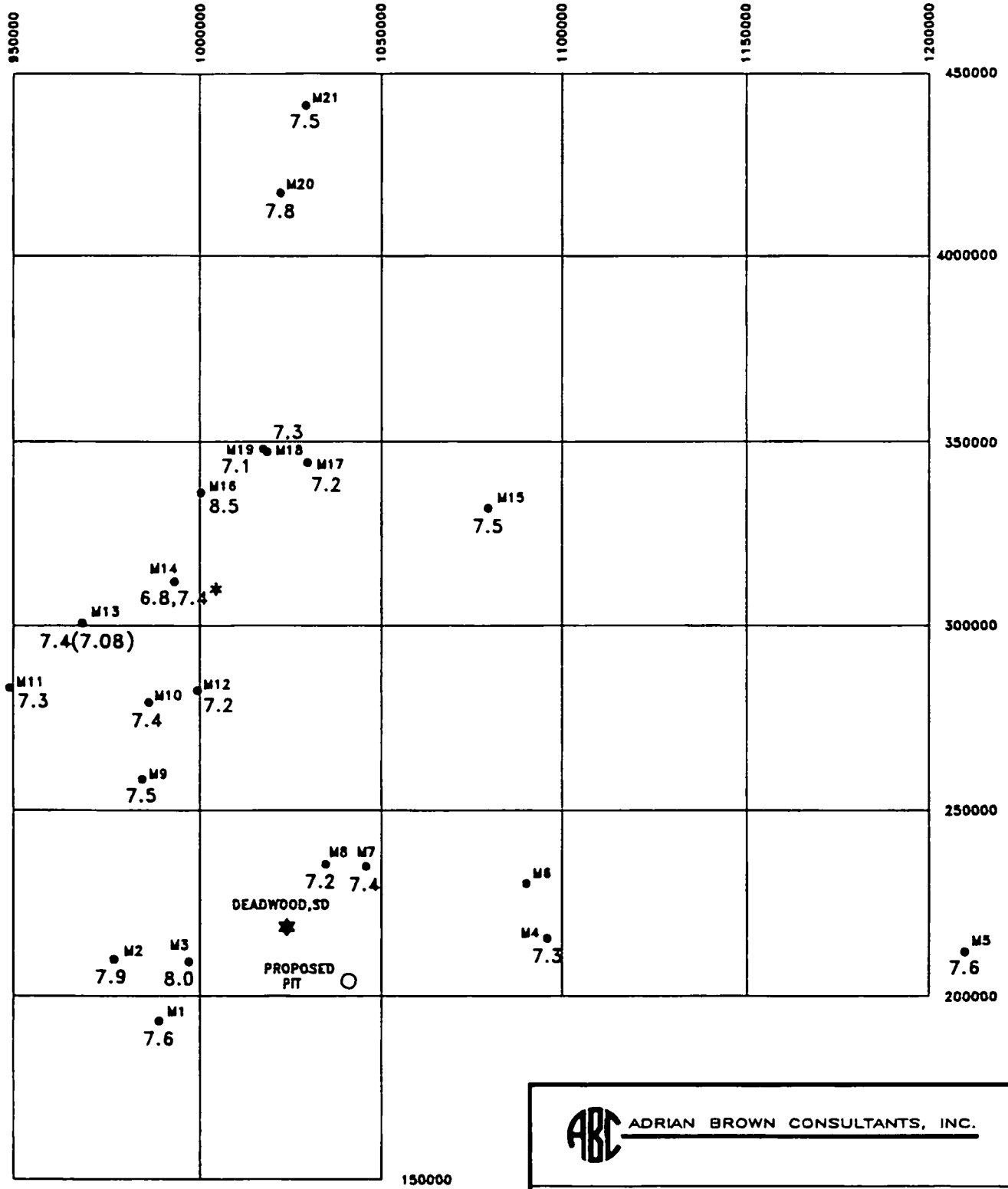
TOTAL HARDNESS (LAB)
(mg/l as $CaCO_3$)

Figure 2



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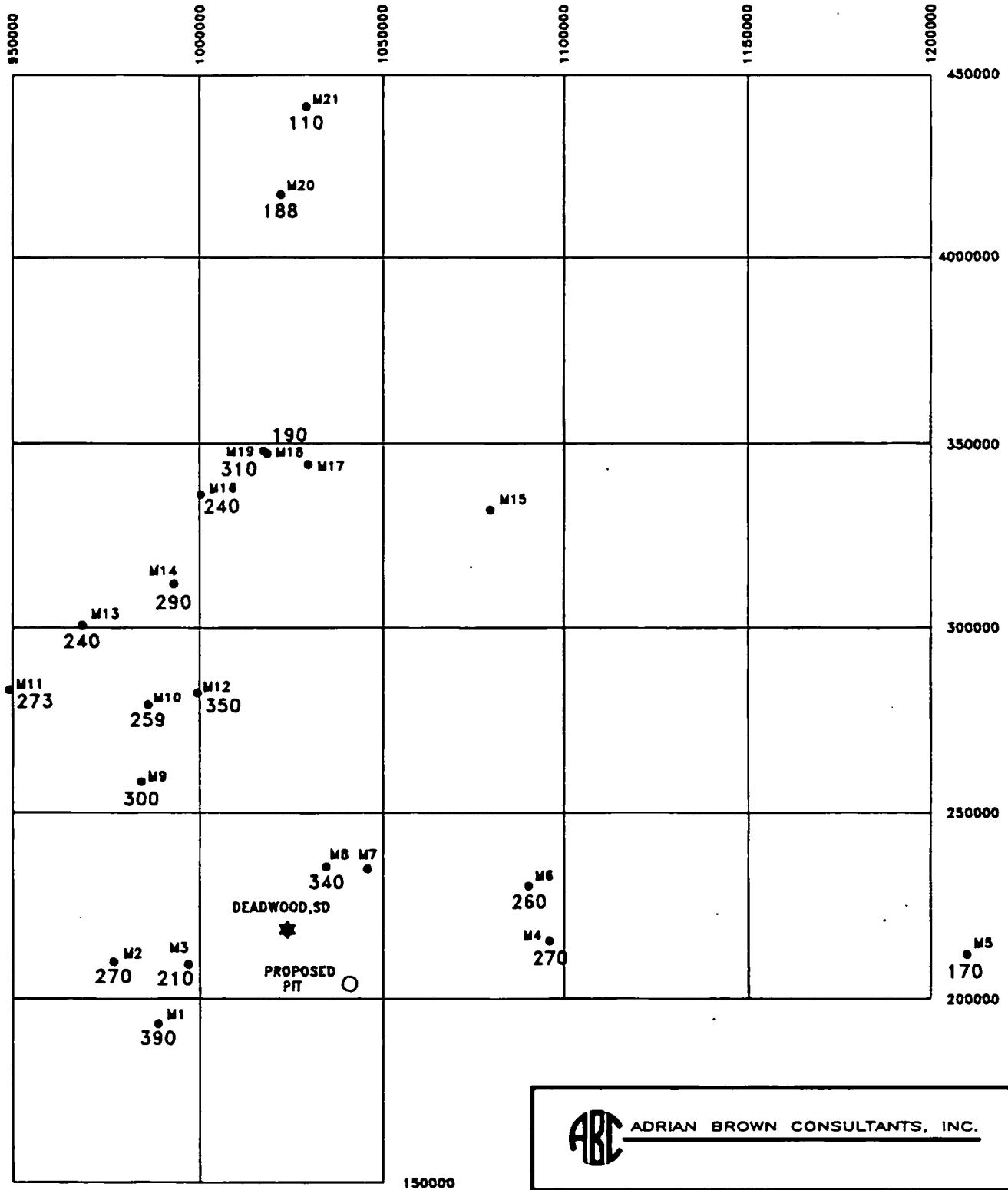
SCALE: 1"=40000'

* DENOTES LAB pH

FIELD ph

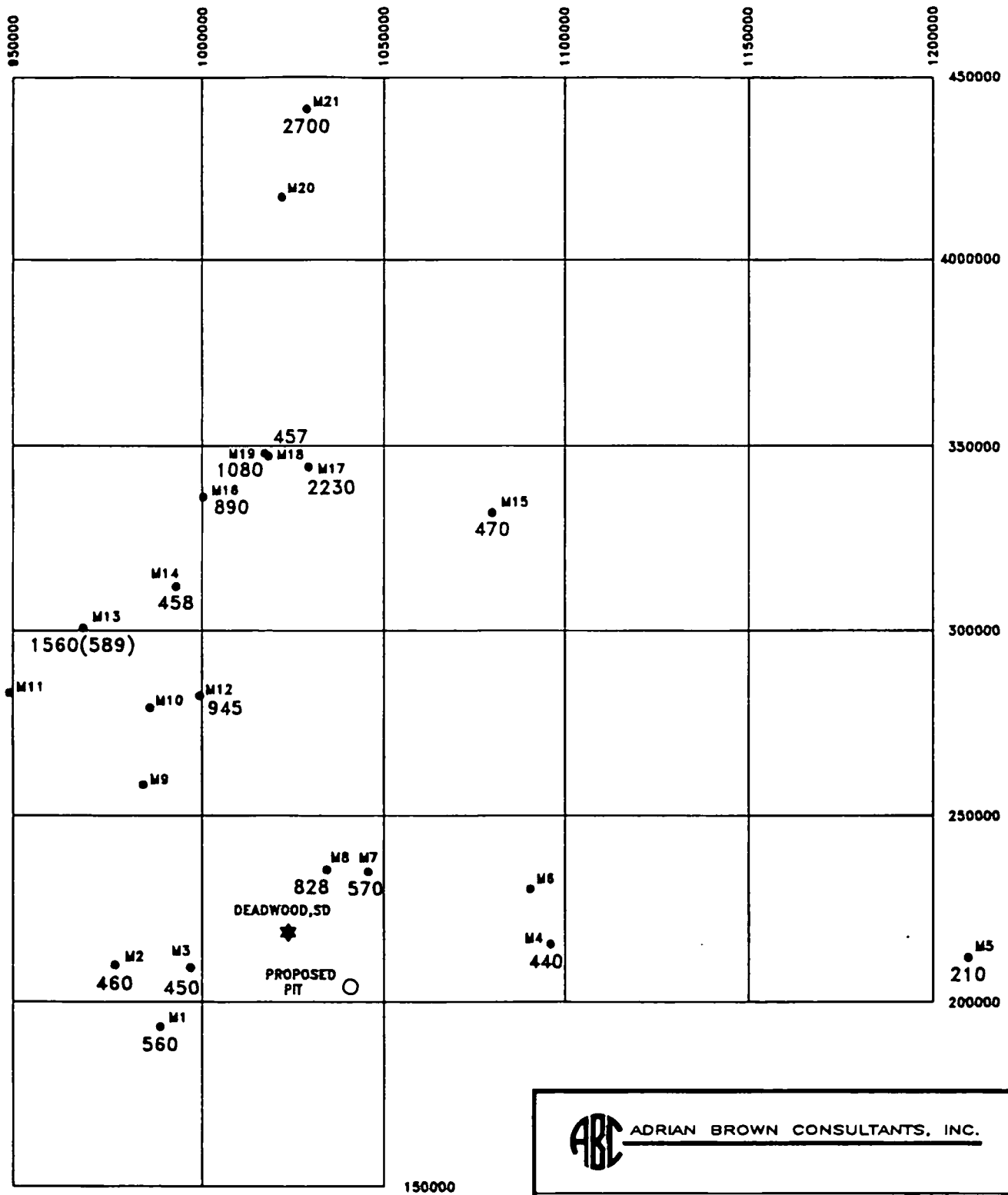
Figure 3



ADRIAN BROWN CONSULTANTS, INC.

BICARBONATE
(mg/l as HCO_3)

Figure 4

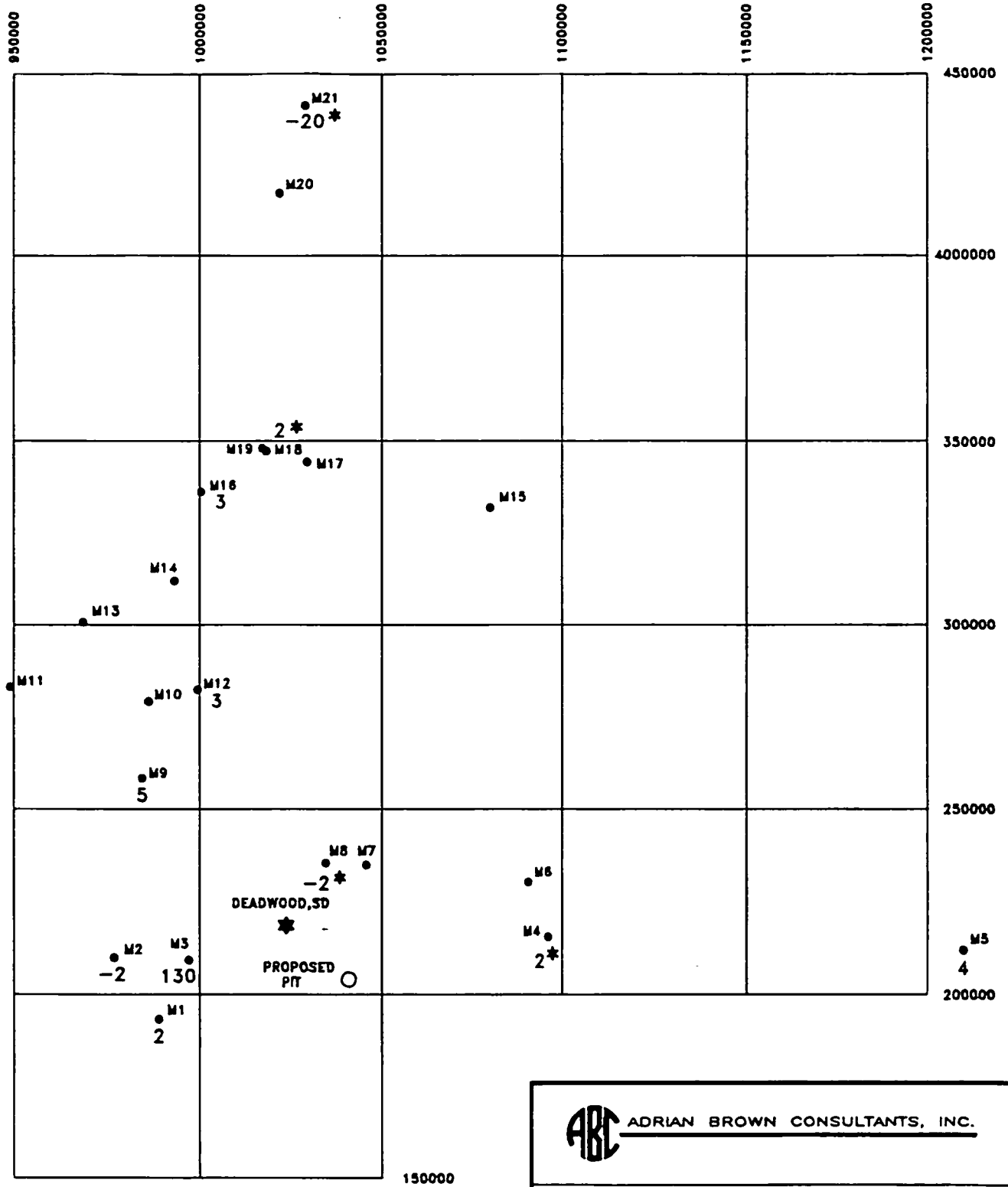


ADRIAN BROWN CONSULTANTS, INC.

SCALE: 1"=40000'

SPECIFIC CONDUCTANCE (Field, us/cm)

Figure 5



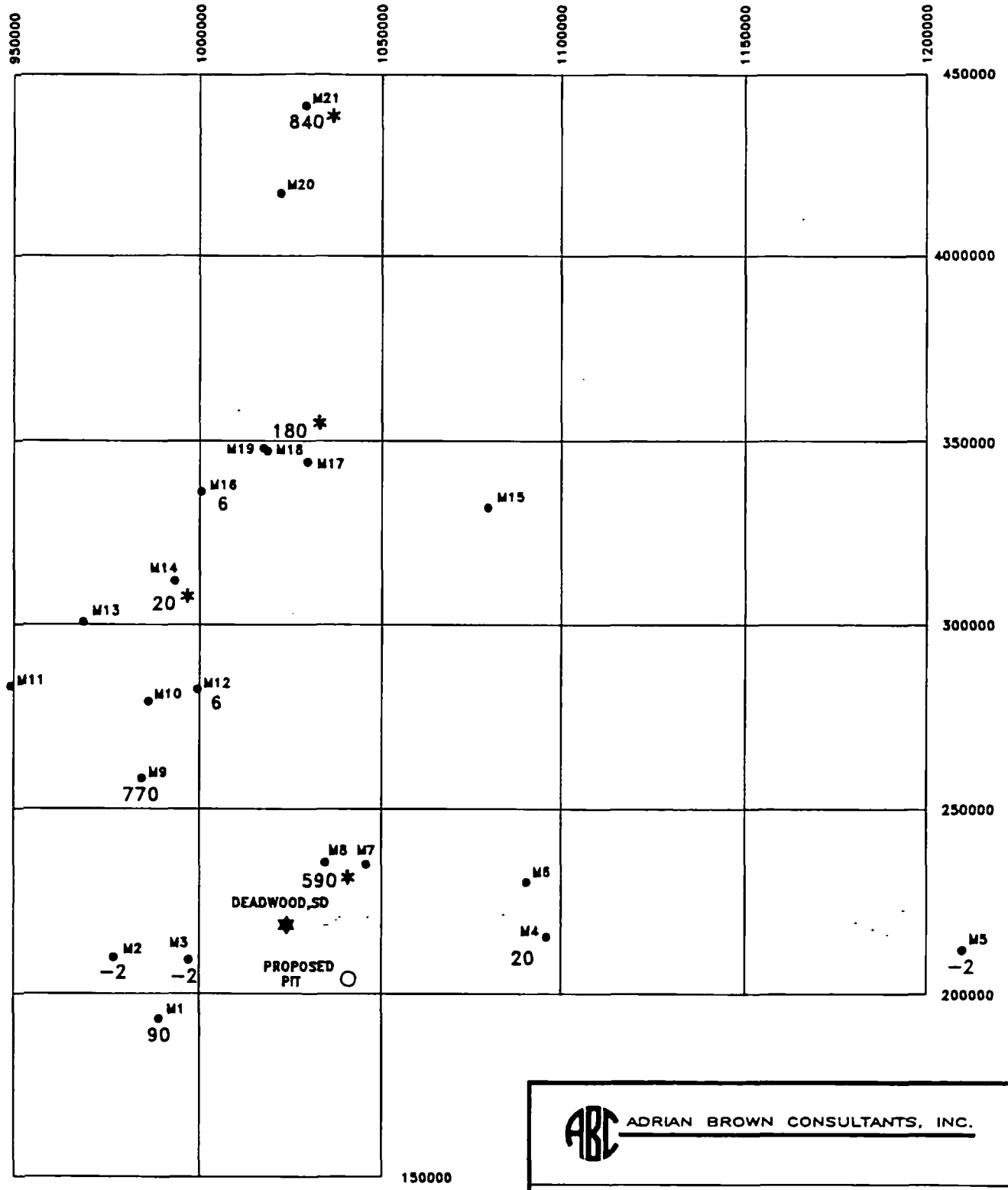
ADRIAN BROWN CONSULTANTS, INC.

COPPER
TOTAL RECOVERABLE
(ug/l as Cu)

SCALE: 1"=40000'

* DISSOLVED Cu

Figure 6



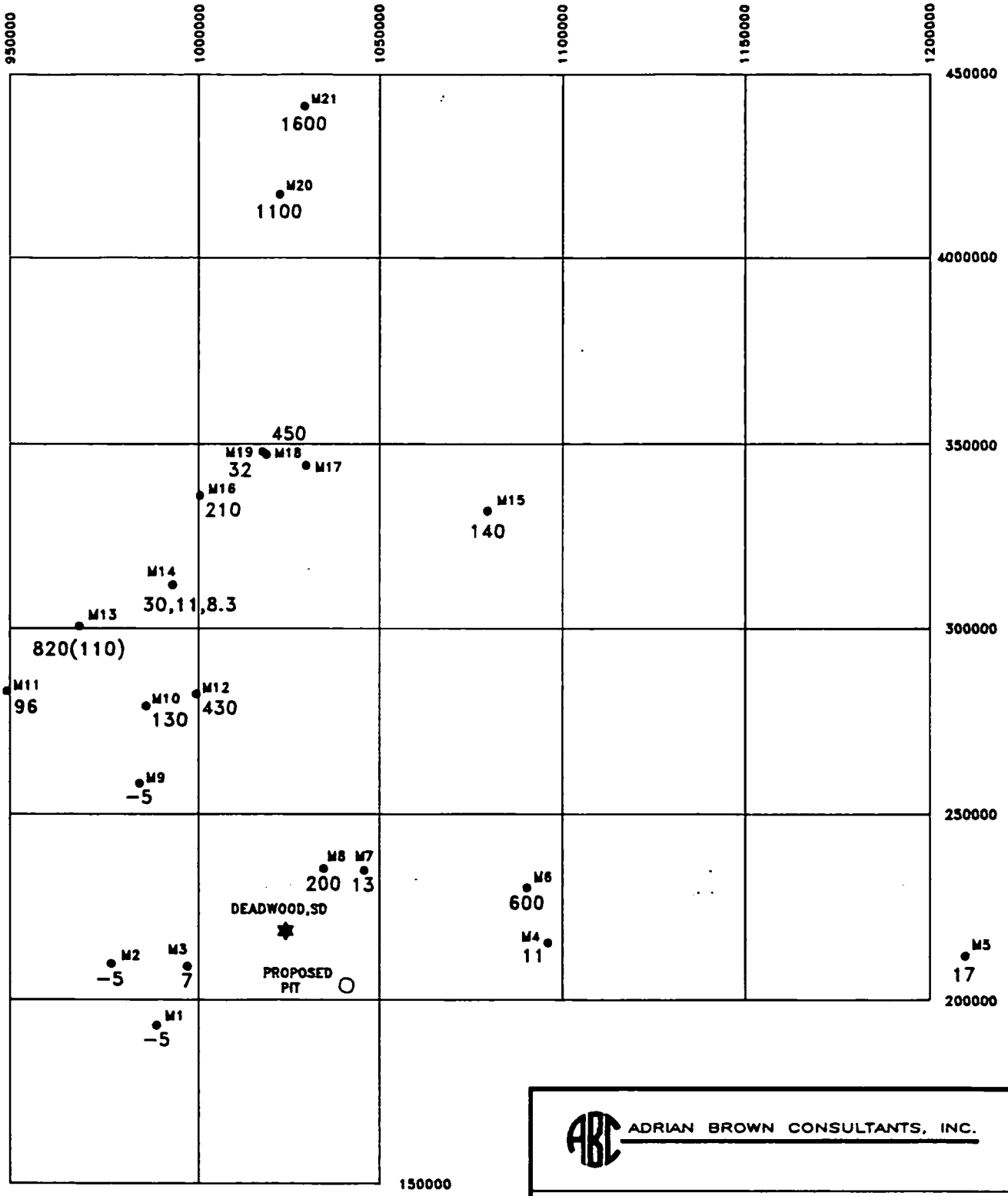
SCALE: 1"=40000'

* DISSOLVED Zn

ADRIAN BROWN CONSULTANTS, INC.

ZINC TOTAL RECOVERABLE (ug/l as Zn)

Figure 7



ADRIAN BROWN CONSULTANTS, INC.

SULFATE (Dissolved) (mg/l as SO_4)

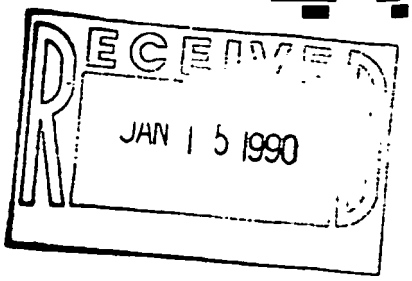
Figure 8

United States Department of the Interior

TAKE PRIDE IN AMERICA

GEOLOGICAL SURVEY

Rm. 237-515 9th Street
Rapid City, South Dakota 57701
January 12, 1990



Adrian Brown
155 South Madison St.
Suite 302
Denver, CO. 80209

Dear Mr. Brown:

Enclosed is the information you asked for. This is the complete water quality database for the Madison Aquifer for the study area in the report by Kyllonen and Peter.

The station name refers to the latitude/longitude location of the well. If you have any questions, please call me at 605-394-1780.

For the Subdistrict Chief:

Sincerely,

Earl A. Greene

Earl A. Greene
Hydrologist

Enclosures

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

STATION NUMBER	DATE	TIME	TEMPERATURE WATER (DEG C) (00010)	AGENCY COLLECTING SAMPLE (CODE NUMBER) (00027)	AGENCY ANALYZING SAMPLE (CODE NUMBER) (00028)	SPECIFIC CONDUCTANCE (US/CM) (00095)	OXYGEN, DISSOLVED (MG/L) (00300)	PH (STANDARD UNITS) (00400)	PH LAB (STANDARD UNITS) (00403)	CARBON DIOXIDE DISSOLVED (MG/L AS CO2) (00405)	ALKALINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)
441749103515701	10-08-79	0105	11.5	84610	84610	560	4.7	7.60	--	16	320
442024103545701	10-18-79	0105	8.0	84610	84610	460	9.5	7.90	--	5.5	220
442027103501301	10-08-79	0105	14.5	84610	84610	450	2.5	8.00	--	3.3	170
442217103272201	08-10-78	--	12.5	--	80020	440	--	7.30	--	22	221
442240103301001	10-08-79	0105	9.0	84610	84610	210	2.6	7.60	--	6.9	138
442440103285501	- -40	0100	10.0	46004	46004	--	--	--	--	--	--
442503103391801	11-14-83	--	7.0	1028	80020	570	--	7.40	7.40	19	--
442504103415301	07-21-78	0900	10.5	--	80020	828	--	7.21	--	33	277
	08-28-79	--	--	--	80020	--	--	--	--	--	--
442822103534501	10-18-79	0105	13.0	84610	84610	510	9.3	7.50	--	15	240
443148103534001	12-04-81	0100	--	1028	1028	--	--	7.38	--	17	--
443210104021601	05-02-80	0100	--	1028	1028	--	--	7.28	--	23	--
443227103503401	09-14-79	0105	12.5	84610	84610	945	11.0	7.20	--	35	282
443511103575801	03-01-74	0100	--	1028	1028	1560	--	7.42	--	15	--
	01-27-79	0100	--	1028	1028	589	--	7.08	--	34	--
443716103522501	08-28-80	0100	22.0	46004	46004	--	--	--	--	--	--
	09-11-80	0100	--	46004	46004	--	--	--	--	--	--
	10-22-80	--	21.5	1028	80020	458	--	6.79	7.40	74	236

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	BICARBONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	CARBONATE WATER WH FET FIELD MG/L AS CO3 (00445)	RESIDUE AT 105 DEG. C, DISSOLVED (MG/L) (00515)	RESIDUE TOTAL AT 105 DEG. C, SUSPENDED (MG/L) (00530)	NITROGEN, TOTAL (MG/L AS N) (00600)	NITROGEN, ORGANIC TOTAL (MG/L AS N) (00605)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N) (00608)	NITROGEN, AMMONIA TOTAL (MG/L AS N) (00610)	NITROGEN, NITRITE DISSOLVED (MG/L AS N) (00613)	NITROGEN, NITRITE TOTAL (MG/L AS N) (00615)	NITROGEN, NITRATE DISSOLVED (MG/L AS N) (00618)
10-08-79	390	0	--	--	--	--	--	--	--	--	--
10-18-79	270	0	--	--	--	--	--	--	--	--	--
10-08-79	210	0	--	--	--	--	--	--	--	--	--
08-10-78	270	0	325	<1	--	--	--	--	--	--	--
10-08-79	170	0	--	--	--	--	--	--	--	--	--
- -40	260	--	--	--	--	--	--	--	--	--	--
11-14-83	--	--	--	--	--	--	--	--	--	--	--
07-21-78	340	0	630	<1	--	--	--	--	--	--	--
08-28-79	--	--	--	--	--	--	--	--	--	--	--
10-18-79	300	0	--	--	--	--	--	--	--	--	--
12-04-81	--	--	--	--	--	--	--	--	--	--	--
05-02-80	--	--	--	--	--	--	--	--	--	--	--
09-14-79	350	0	--	--	--	--	--	--	--	--	--
03-01-74	240	--	--	--	--	--	--	--	--	--	--
01-27-79	260	--	--	--	--	--	--	--	--	--	--
08-28-80	--	--	--	--	--	--	--	--	--	--	--
09-11-80	--	--	--	--	--	--	--	--	--	--	--
10-22-80	290	--	--	--	0.27	0.10	0.00	0.020	0.00	0.00	0.130

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	NITROGEN, NITRATE TOTAL (MG/L AS N) (00620)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N) (00625)	NITROGEN, NO2+NO3 TOTAL (MG/L AS N) (00630)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N) (00631)	PHOSPHOROUS TOTAL (MG/L AS P) (00665)	PHOSPHOROUS DISSOLVED (MG/L AS P) (00666)	CARBON, ORGANIC DISSOLVED (MG/L AS C) (00681)	CYANIDE TOTAL (MG/L AS CN) (00720)	SULFIDE TOTAL (MG/L AS S) (00745)	HARDNESS TOTAL (MG/L AS CACO3) (00900)	HARDNESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)
10-08-79	--	--	--	--	<0.040	--	--	--	--	290	0
10-18-79	--	--	--	--	<0.040	--	--	--	--	230	7
10-08-79	--	--	--	--	0.057	--	--	--	--	150	0
08-10-78	--	0.08	--	--	--	0.010	0.5	--	0.2	230	12
10-08-79	--	--	--	--	<0.040	--	--	--	--	7	0
- -40	3.30	--	--	--	--	--	--	--	--	760	540
11-14-83	--	--	--	--	--	--	--	<0.010	--	260	15
07-21-78	--	0.17	--	--	--	<0.010	1.1	--	0.5	480	200
08-28-79	--	--	--	--	--	--	--	0.010	--	--	--
10-18-79	--	--	--	--	<0.040	--	--	--	--	250	7
12-04-81	--	--	--	--	--	--	--	--	--	370	160
05-02-80	--	--	--	--	--	--	--	--	--	340	120
09-14-79	--	--	--	--	<0.040	--	--	--	--	620	340
03-01-74	--	--	--	--	--	--	--	--	--	840	650
01-27-79	--	--	--	--	--	--	--	--	--	310	98
08-28-80	<0.100	--	--	--	--	--	--	--	--	240	240
09-11-80	<0.100	--	--	--	--	--	--	--	--	240	240
10-22-80	0.150	0.12	0.150	0.130	--	0.220	3.6	--	0	230	0

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	POTAS-SIUM, TOTAL RECOV-ERABLE (MG/L AS K) (00937)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)
10-08-79	60	34	3.1	0.1	--	--	1.4	<10	<5.0	--	4.1
10-18-79	43	29	1.6	0.0	--	--	1.5	<10	<5.0	--	4.2
10-08-79	43	11	4.1	0.1	--	--	0.7	<10	7.0	--	5.5
08-10-78	55	23	2.3	0.1	2	1.3	--	1.8	11	0.30	10
10-08-79	1.0	1.0	0.20	0.0	--	--	0.1	<10	17	--	0.10
- -40	210	56	--	--	--	--	--	--	600	0.70	--
11-14-83	79	15	1.5	0.0	1	1.2	--	1.1	13	0.10	9.5
07-21-78	88	63	5.8	0.1	3	3.6	--	3.9	200	0.20	12
08-28-79	--	--	--	--	--	--	--	--	--	--	--
10-18-79	56	26	1.0	0.0	--	--	1.1	<10	<5.0	--	4.6
12-04-81	92	34	2.0	0.0	1	1.0	--	4.0	130	--	--
05-02-80	98	23	2.0	0.0	1	1.0	--	3.0	96	--	--
09-14-79	170	48	5.4	0.1	--	--	2.0	<10	430	--	5.2
03-01-74	250	53	2.0	0.0	0	2.0	--	3.0	820	--	--
01-27-79	82	26	2.0	0.0	1	1.0	--	3.0	110	--	--
08-28-80	54	25	<5.0	--	--	--	--	<2.0	30	0.28	--
09-11-80	55	24	2.0	0.1	--	--	--	<2.0	11	0.27	--
10-22-80	54	23	1.8	0.0	2	1.1	--	1.3	8.3	0.40	11

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	POTAS-SIUM, TOTAL RECOV-ERABLE (MG/L AS K) (00937)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)
10-08-79	60	34	3.1	0.1	--	--	1.4	<10	<5.0	--	4.1
10-18-79	43	29	1.6	0.0	--	--	1.5	<10	<5.0	--	4.2
10-08-79	43	11	4.1	0.1	--	--	0.7	<10	7.0	--	5.5
08-10-78	55	23	2.3	0.1	2	1.3	--	1.8	11	0.30	10
10-08-79	1.0	1.0	0.20	0.0	--	--	0.1	<10	17	--	0.10
- -40	210	56	--	--	--	--	--	--	600	0.70	--
11-14-83	79	15	1.5	0.0	1	1.2	--	1.1	13	0.10	9.5
07-21-78	88	63	5.8	0.1	3	3.6	--	3.9	200	0.20	12
08-28-79	--	--	--	--	--	--	--	--	--	--	--
10-18-79	56	26	1.0	0.0	--	--	1.1	<10	<5.0	--	4.6
12-04-81	92	34	2.0	0.0	1	1.0	--	4.0	130	--	--
05-02-80	98	23	2.0	0.0	1	1.0	--	3.0	96	--	--
09-14-79	170	48	5.4	0.1	--	--	2.0	<10	430	--	5.2
03-01-74	250	53	2.0	0.0	0	2.0	--	3.0	820	--	--
01-27-79	82	26	2.0	0.0	1	1.0	--	3.0	110	--	--
08-28-80	54	25	<5.0	--	--	--	--	<2.0	30	0.28	--
09-11-80	55	24	2.0	0.1	--	--	--	<2.0	11	0.27	--
10-22-80	54	23	1.8	0.0	2	1.1	--	1.3	8.3	0.40	11

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UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	ARSENIC TOTAL (UG/L AS AS) (01002)	BARIUM, DIS-SOLVED (UG/L AS BA) (01005)	BARIUM, TOTAL RECOV-ERABLE (UG/L AS BA) (01007)	BORON, DIS-SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV-ERABLE (UG/L AS B) (01022)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR) (01034)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO) (01037)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)
10-08-79	--	<0	--	50	--	20	--	--	<4	<2	--
10-18-79	--	<0	--	20	--	20	--	--	<4	<2	--
10-08-79	--	4	--	30	--	9	--	--	<4	3	--
08-10-78	2	--	300	--	<20	--	<2	ND	--	--	2
10-08-79	--	0	--	10	--	170	--	--	10	3	--
- -40	--	--	--	--	--	--	--	--	--	--	--
11-14-83	--	3	--	--	--	--	--	--	--	--	--
07-21-78	1	--	50	--	<20	--	3	ND	--	--	<2
08-28-79	--	--	--	--	--	--	ND	--	--	--	--
10-18-79	--	1	--	50	--	10	--	--	<4	<2	--
12-04-81	--	--	--	--	20	--	--	--	--	--	--
05-02-80	--	--	--	--	--	--	--	--	--	--	--
09-14-79	--	1	--	20	--	60	--	--	<4	2	--
03-01-74	--	--	--	--	--	--	--	--	--	--	--
01-27-79	--	--	--	--	--	--	--	--	--	--	--
08-28-80	--	--	--	--	--	--	--	--	--	--	--
09-11-80	--	--	--	--	--	--	--	--	--	--	--
10-22-80	4	--	200	--	0	--	<1	0	--	--	7

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU) (01042)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	MOLYB-DENUM, TOTAL RECOV-ERABLE (UG/L AS MO) (01062)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI) (01067)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG) (01077)	STRON-TIUM, DIS-SOLVED (UG/L AS SR) (01080)
10-08-79	2	20	--	--	<2	--	--	4	<4	<2	--
10-18-79	<2	20	--	--	<2	--	--	<4	<4	<2	--
10-08-79	130	10	--	--	<2	--	--	6	<4	<2	--
08-10-78	--	--	20	3	--	5	7	--	--	--	330
10-08-79	4	<10	--	--	2	--	--	7	19	<2	--
- -40	--	1700	--	--	--	--	--	--	--	--	--
11-14-83	--	--	--	--	--	--	--	--	--	--	--
07-21-78	--	--	<10	29	--	3	1	--	--	--	500
08-28-79	--	--	--	ND	--	--	--	--	--	--	--
10-18-79	5	10	--	--	4	--	--	<4	<4	<2	--
12-04-81	--	--	--	--	--	--	--	--	--	--	--
05-02-80	--	--	--	--	--	--	--	--	--	--	--
09-14-79	3	20	--	--	2	--	--	<4	<4	<2	--
03-01-74	--	--	--	--	--	--	--	--	--	--	--
01-27-79	--	--	--	--	--	--	--	--	--	--	--
08-28-80	--	<50	--	--	<50	--	--	--	--	--	--
09-11-80	--	<50	--	--	<50	--	--	--	--	--	--
10-22-80	--	--	20	3	--	<1	<10	--	--	--	320

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	STRONTIUM, TOTAL RECOVERABLE (UG/L AS SR) (01082)	VANADIUM, DISSOLVED (UG/L AS V) (01085)	VANADIUM, TOTAL (UG/L AS V) (01087)	ZINC, DISSOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN) (01092)	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL) (01105)	ALUMINUM, DISSOLVED (UG/L AS AL) (01106)	LITHIUM DISSOLVED (UG/L AS LI) (01130)	LITHIUM TOTAL RECOVERABLE (UG/L AS LI) (01132)	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	SELENIUM, TOTAL (UG/L AS SE) (01147)
10-08-79	80	--	<4	--	90	<10	--	--	5	--	0
10-18-79	100	--	<4	--	120	<10	--	--	4	--	0
10-08-79	80	--	<4	--	290	<10	--	--	3	--	<0
08-10-78	--	1	--	20	--	--	<100	<4	--	3	--
10-08-79	5	--	49	--	40	<10	--	--	2	--	1
- -40	--	--	--	--	--	--	--	--	--	--	--
11-14-83	--	--	--	--	--	--	--	--	--	--	--
07-21-78	--	0	--	590	--	--	20	7	--	1	--
08-28-79	--	--	--	--	--	--	--	--	--	--	--
10-18-79	130	--	<4	--	770	<10	--	--	3	--	0
12-04-81	--	--	--	--	--	--	--	--	--	--	--
05-02-80	--	--	--	--	--	--	--	--	--	--	--
09-14-79	2300	--	<4	--	6	<10	--	--	10	--	0
03-01-74	--	--	--	--	--	--	--	--	--	--	--
01-27-79	--	--	--	--	--	--	--	--	--	--	--
08-28-80	--	--	--	--	--	--	--	--	--	--	--
09-11-80	--	--	--	--	--	--	--	--	--	--	--
10-22-80	--	1	--	20	--	--	20	6	--	1	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	TI-TANIUM, TOTAL (UG/L AS TI) (01152)	ZIR-CONIUM, TOTAL (UG/L AS ZR) (01162)	SCAN-DIUM TOTAL (UG/L AS SC) (01189)	GROSS ALPHA, DIS-SOLVED (PCI/L AS U-NAT) (01515)	GROSS ALPHA, SUSP. TOTAL (PCI/L AS U-NAT) (01516)	GROSS BETA, DIS-SOLVED (PCI/L AS CS-137) (03515)	GROSS BETA, SUSP. TOTAL (PCI/L AS CS-137) (03516)	RADIUM 226, DIS-SOLVED, RADON METHOD (PCI/L) (09511)	URANIUM NATURAL DIS-SOLVED (UG/L AS U) (22703)	URANIUM NATURAL TOTAL (UG/L AS U) (28011)	CERIUM 144, TOTAL (PCI/L) (28901)
10-08-79	<2	<2	--	--	--	--	--	--	--	3.2	<30
10-18-79	<2	<2	--	--	--	--	--	--	--	1.2	<30
10-08-79	<2	<2	--	--	--	--	--	--	--	0.86	<30
08-10-78	--	--	--	12	<0.3	3.2	0.5	--	--	--	--
10-08-79	10	<2	6.0	--	--	--	--	--	--	1.2	<30
-40	--	--	--	--	--	--	--	--	--	--	--
11-14-83	--	--	--	--	--	--	--	--	--	--	--
07-21-78	--	--	--	<3.0	<0.3	3.6	<0.4	--	--	--	--
08-28-79	--	--	--	--	--	--	--	--	--	--	--
10-18-79	<2	<2	--	--	--	--	--	--	--	2.0	<30
12-04-81	--	--	--	--	--	--	--	--	--	--	--
05-02-80	--	--	--	--	--	--	--	--	--	--	--
09-14-79	<2	<2	--	--	--	--	--	--	--	3.9	<30
03-01-74	--	--	--	--	--	--	--	--	--	--	--
01-27-79	--	--	--	--	--	--	--	--	--	--	--
08-28-80	--	--	--	--	--	--	--	--	--	--	--
09-11-80	--	--	--	--	--	--	--	--	--	--	--
10-22-80	--	--	--	14	--	4.4	--	1.3	3.7	--	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, AMMONIA TOTAL (MG/L AS NH4) (71845)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS NH4) (71846)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS NO2) (71856)	IODIDE, DIS-SOLVED (MG/L AS I) (71865)	BROMIDE DIS-SOLVED (MG/L AS BR) (71870)	NITRO-GEN, TOTAL (MG/L AS NO3) (71887)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)
10-08-79	--	--	--	--	--	--	--	--	--	--	--
10-18-79	--	--	--	--	--	--	--	--	--	--	--
10-08-79	--	--	--	--	--	--	--	--	--	--	--
08-10-78	226	238	0.31	--	--	--	--	0.00	0.00	--	0.3
10-08-79	--	--	--	--	--	--	--	--	--	--	--
- -40	1060	--	--	--	--	--	--	--	--	--	--
11-14-83	265	267	0.36	--	--	--	--	--	--	--	--
07-21-78	571	544	0.78	--	--	--	--	0.00	0.00	--	<0.1
08-28-79	--	--	--	--	--	--	--	--	--	--	--
10-18-79	--	--	--	--	--	--	--	--	--	--	--
12-04-81	--	395	0.54	--	--	--	--	--	--	--	--
05-02-80	--	357	0.49	--	--	--	--	--	--	--	--
09-14-79	--	--	--	--	--	--	--	--	--	--	--
03-01-74	--	1250	1.70	--	--	--	--	--	--	--	--
01-27-79	--	356	0.48	--	--	--	--	--	--	--	--
08-28-80	220	--	--	--	--	--	--	--	--	--	--
09-11-80	190	--	--	--	--	--	--	--	--	--	--
10-22-80	228	244	0.31	0.02	0.0	0.58	0.0	0.00	0.00	1.2	0

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	ELEV. OF LAND SURFACE DATUM (FT. ABOVE NGVD) (72000)	DEPTH OF WELL, TOTAL (FEET) (72008)	GROSS ALPHA, DIS-SOLVED (UG/L AS U-NAT) (80030)	GROSS ALPHA, SUSP. TOTAL (UG/L AS U-NAT) (80040)	GROSS BETA, DIS-SOLVED (PCI/L AS SR/YT-90) (80050)	GROSS BETA, SUSP. TOTAL (PCI/L AS SR/YT-90) (80060)	THORIUM TOTAL (UG/L AS TH) (82364)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	ALKA-LINITY LAB (MG/L AS CACO3) (90410)	BICAR-BONATE IT-LAB (MG-L - HCO3) (90440)	BICAR-BONATE IT-FLD (MG/L AS HCO3) (99440)
10-08-79	5330	26.20	--	--	--	--	<5.0	--	--	--	--
10-18-79	6321	72.20	--	--	--	--	<5.0	--	--	--	--
10-08-79	6400	49.20	--	--	--	--	<5.0	--	--	--	--
08-10-78	3625	1465.00	18	<0.4	3.0	0.6	--	--	--	--	--
10-08-79	3750	29.50	--	--	--	--	<5.0	--	--	--	--
- -40	3335	1800.00	--	--	--	--	--	--	--	--	--
11-14-83	3960	--	--	--	--	--	--	447	252	--	298
07-21-78	4360	550.00	<4.4	<0.4	3.3	<0.4	--	--	--	--	--
08-28-79	4360	550.00	--	--	--	--	--	--	--	--	--
10-18-79	4226	984.00	--	--	--	--	<5.0	--	--	--	--
12-04-81	3510	1125.00	--	--	--	--	--	650	--	259	--
05-02-80	3581	840.00	--	--	--	--	--	608	--	273	--
09-14-79	3382	496.00	--	--	--	--	<5.0	--	--	--	--
03-01-74	3380	1426.00	--	--	--	--	--	--	--	--	--
01-27-79	3380	1426.00	--	--	--	--	--	--	--	--	--
08-28-80	3242	2220.00	--	--	--	--	--	489	--	--	--
09-11-80	3242	2220.00	--	--	--	--	--	437	--	--	--
10-22-80	3242	2220.00	20	--	4.0	--	--	446	230	--	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

STATION NUMBER	DATE	TIME	TEMPERATURE WATER (DEG C) (00010)	AGENCY COLLECTING SAMPLE (CODE NUMBER) (00027)	AGENCY ANALYZING SAMPLE (CODE NUMBER) (00028)	SPECIFIC CONDUCTANCE (US/CM) (00095)	OXYGEN, DISSOLVED (MG/L) (00300)	PH (STANDARD UNITS) (00400)	CARBON DIOXIDE DISSOLVED (MG/L AS CO2) (00405)	ALKALINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKALINITY, METHYL ORANGE (MG/L) (00411)
444114103323901	03-11-81	0100	--	1028	1028	470	--	7.49	12	--	--
444116103510301	09-08-79	0105	17.5	84610	84610	890	1.9	8.50	1.2	187	--
444248103442501	- -76	0100	--	1028	1028	2230	--	7.21	--	156	--
	00-00-76	0100	--	1028	1028	2230	--	7.21	--	156	--
444312103465901	08-23-78	--	41.5	1028	80020	1080	--	7.10	23	153	--
444320103471801	04-14-76	0100	--	1028	1028	457	--	7.32	23	--	--
445440103465901	01-30-62	0100	--	46004	46004	--	--	7.80	4.7	--	150
445842103454301	08-11-78	--	23.0	1028	80020	2700	--	7.50	5.5	90	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	BICARBONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	CARBONATE WATER WH FET FIELD MG/L AS CO3 (00445)	RESIDUE AT 105 DEG. C, DISSOLVED (MG/L) (00515)	RESIDUE TOTAL AT 105 DEG. C, SUSPENDED (MG/L) (00530)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N) (00625)	PHOSPHOROUS TOTAL (MG/L AS P) (00665)	PHOSPHOROUS DISSOLVED (MG/L AS P) (00666)	CARBON, ORGANIC DISSOLVED (MG/L AS C) (00681)	SULFIDE TOTAL (MG/L AS S) (00745)	HARDNESS TOTAL (MG/L AS CACO3) (00900)	HARDNESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DISSOLVED (MG/L AS CA) (00915)
03-11-81	240	--	--	--	--	--	--	--	--	350	150	96
09-08-79	240	11	--	--	--	<0.040	--	--	--	22	0	5.6
- -76	--	--	--	--	--	--	--	--	--	1200	1000	320
00-00-76	--	--	--	--	--	--	--	--	--	1200	1000	320
08-23-78	190	0	963	<1	0.05	--	0.010	0.8	0.2	610	460	160
04-14-76	310	--	--	--	--	--	--	--	--	290	38	78
01-30-62	--	--	--	--	--	--	--	--	--	1400	--	--
08-11-78	110	0	3180	22	0.11	--	<0.010	1.4	0.2	1700	1700	510

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)	SODIUM ADSORPTION RATIO (00931)	SODIUM PERCENT (00932)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	POTASSIUM, TOTAL RECOVERABLE (MG/L AS K) (00937)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SILICA, DISSOLVED (MG/L AS SIO2) (00955)	ARSENIC DISSOLVED (UG/L AS AS) (01000)
03-11-81	26	5.0	0.1	3	1.0	--	9.0	140	--	--	--
09-08-79	2.0	190	19	--	--	2.9	<10	210	--	3.6	--
- -76	89	39	0.5	7	14	--	41	--	--	--	--
00-00-76	89	39	0.5	7	14	--	41	--	--	--	--
08-23-78	51	14	0.3	5	5.0	--	17	450	1.7	20	3
04-14-76	23	2.0	0.0	1	1.0	--	3.0	32	--	--	--
01-30-62	--	--	--	--	--	--	--	1100	--	--	--
08-11-78	110	36	0.4	4	35	--	25	1600	3.1	17	2

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	ARSENIC TOTAL (UG/L AS AS) (01002)	BARIUM, DIS-SOLVED (UG/L AS BA) (01005)	BARIUM, TOTAL RECOV-ERABLE (UG/L AS BA) (01007)	BORON, DIS-SOLVED (UG/L AS B) (01020)	BORON, TOTAL RECOV-ERABLE (UG/L AS B) (01022)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR) (01034)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO) (01037)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU) (01042)
03-11-81	--	--	--	--	--	--	--	--	--	--	--
09-08-79	<0	--	10	--	30	--	--	<4	3	--	<2
- -76	--	--	--	--	--	--	--	--	--	--	--
00-00-76	--	--	--	--	--	--	--	--	--	--	--
08-23-78	--	<100	--	50	--	ND	ND	--	--	2	--
04-14-76	--	--	--	--	--	--	--	--	--	--	--
01-30-62	--	--	--	--	--	--	--	--	--	--	--
08-11-78	--	<100	--	140	--	ND	<20	--	--	ND	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	MOLYB-DENUM, TOTAL RECOV-ERABLE (UG/L AS MO) (01062)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI) (01067)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG) (01077)	STRON-TIUM, DIS-SOLVED (UG/L AS SR) (01080)	STRON-TIUM, TOTAL RECOV-ERABLE (UG/L AS SR) (01082)
03-11-81	--	--	--	--	--	--	--	--	--	--	--
09-08-79	20	--	--	<2	--	--	7	<4	<2	--	130
- -76	--	--	--	--	--	--	--	--	--	--	--
00-00-76	--	--	--	--	--	--	--	--	--	--	--
08-23-78	--	40	4	--	<10	17	--	--	--	3300	--
04-14-76	--	--	--	--	--	--	--	--	--	--	--
01-30-62	--	--	--	--	--	--	--	--	--	--	--
08-11-78	--	7900	ND	--	150	34	--	--	--	12000	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

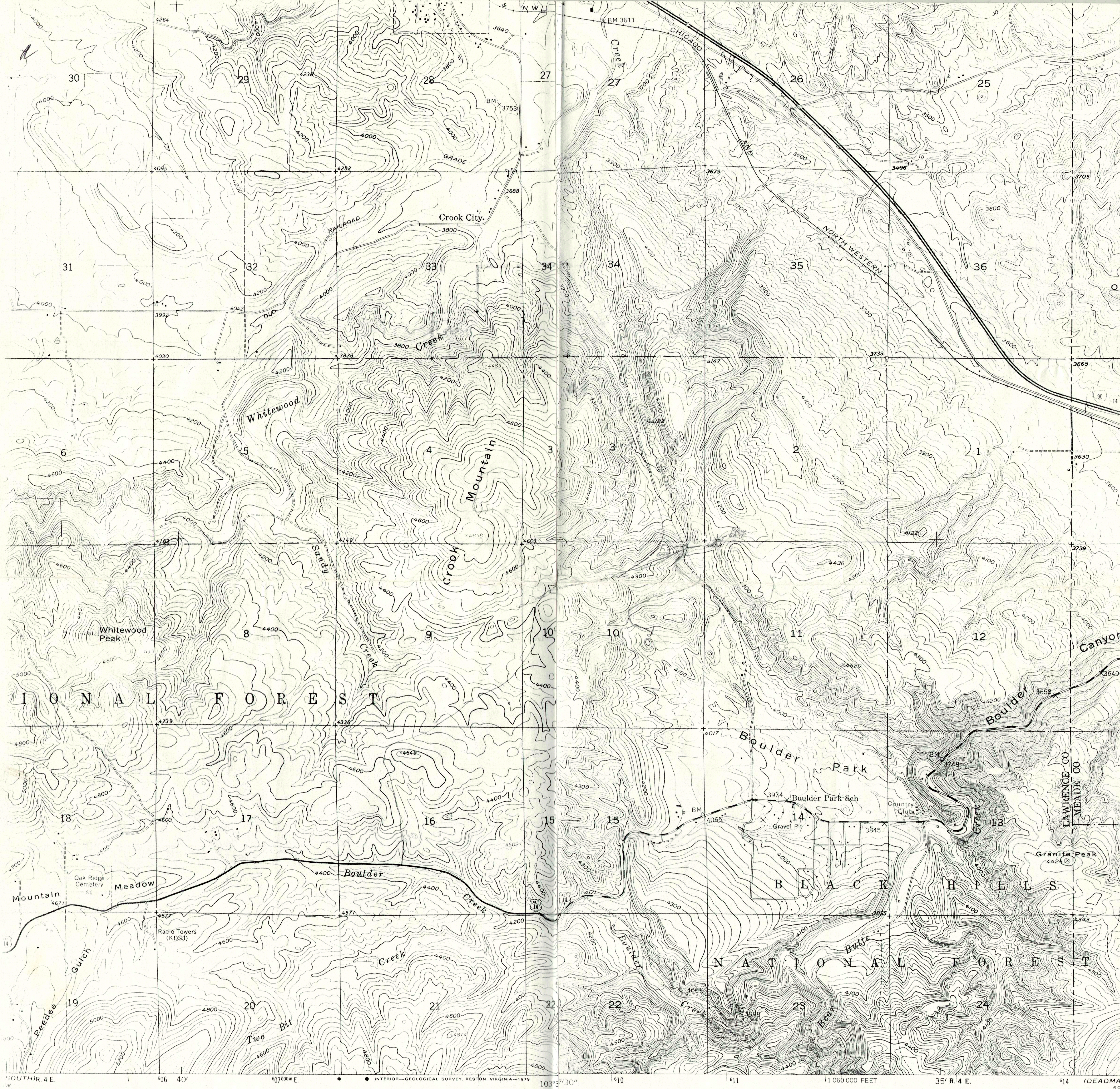
DATE	VANADIUM, DISSOLVED (UG/L AS V) (01085)	VANADIUM, TOTAL (UG/L AS V) (01087)	ZINC, DISSOLVED (UG/L AS ZN) (01090)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN) (01092)	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL) (01105)	ALUMINUM, DISSOLVED (UG/L AS AL) (01106)	LITHIUM DISSOLVED (UG/L AS LI) (01130)	LITHIUM TOTAL RECOVERABLE (UG/L AS LI) (01132)	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	SELENIUM, TOTAL (UG/L AS SE) (01147)	TITANIUM, TOTAL (UG/L AS TI) (01152)
03-11-81	--	--	--	--	--	--	--	--	--	--	--
09-08-79	--	4	--	6	10	--	--	100	--	0	<2
- -76	--	--	--	--	--	--	--	--	--	--	--
00-00-76	--	--	--	--	--	--	--	--	--	--	--
08-23-78	5	--	180	--	--	<100	20	--	8	--	--
04-14-76	--	--	--	--	--	--	--	--	--	--	--
01-30-62	--	--	--	--	--	--	--	--	--	--	--
08-11-78	0	--	840	--	--	<100	90	--	<1	--	--

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	ZIR-CONIUM, TOTAL (UG/L AS ZR) (01162)	GROSS ALPHA, DIS-SOLVED (PCI/L AS U-NAT) (01515)	GROSS ALPHA, SUSP. TOTAL (PCI/L AS U-NAT) (01516)	GROSS BETA, DIS-SOLVED (PCI/L AS CS-137) (03515)	GROSS BETA, SUSP. TOTAL (PCI/L AS CS-137) (03516)	URANIUM NATURAL TOTAL (UG/L AS U) (28011)	CERIUM 144, TOTAL (PCI/L) (28901)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	IODIDE, DIS-SOLVED (MG/L AS I) (71865)
03-11-81	--	--	--	--	--	--	--	--	397	0.54	--
09-08-79	<2	--	--	--	--	0.57	<30	--	--	--	--
-76	--	--	--	--	--	--	--	--	--	--	--
00-00-76	--	--	--	--	--	--	--	--	--	--	--
08-23-78	--	12	<0.3	8.7	0.5	--	--	869	814	1.18	0.040
04-14-76	--	--	--	--	--	--	--	--	290	0.39	--
01-30-62	--	--	--	--	--	--	--	--	--	--	--
08-11-78	--	55	1.6	38	0.8	--	--	2750	2410	3.74	0.010

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY PROCESS DATE 1-12-90
MULTIPLE STATION ANALYSES

DATE	BROMIDE DIS-SOLVED (MG/L AS BR) (71870)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	ELEV. OF LAND SURFACE DATUM (FT. ABOVE NGVD) (72000)	DEPTH OF WELL, TOTAL (FEET) (72008)	GROSS ALPHA, DIS-SOLVED (UG/L AS U-NAT) (80030)	GROSS ALPHA, SUSP. TOTAL (UG/L AS U-NAT) (80040)	GROSS BETA, DIS-SOLVED (PCI/L AS SR/YT-90) (80050)	GROSS BETA, SUSP. TOTAL (PCI/L AS SR/YT-90) (80060)	THORIUM TOTAL (UG/L AS TH) (82364)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	BICAR-BONATE IT-LAB (MG-L - HCO3) (90440)
03-11-81	--	--	2835	3930.00	--	--	--	--	--	--	--
09-08-79	--	--	3035	698.00	--	--	--	--	<5.0	--	--
- -76	--	--	3053	3240.00	--	--	--	--	--	--	--
00-00-76	--	--	3053	3240.00	--	--	--	--	--	--	--
08-23-78	0.40	<0.1	3099	3511.00	18	<0.4	7.9	0.6	--	--	--
04-14-76	--	--	3135	3197.00	--	--	--	--	--	--	--
01-30-62	--	--	3002	--	--	--	--	--	--	299	188
08-11-78	0.10	<0.1	3205	4850.00	81	2.4	34	0.8	--	--	--



(SOUTH) R. 4 E. | 606 | 40′ | 607000m E. | INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1979 | 103°37′30″ | 610 | 611 | 1 060 000 FEET | 35′ R. 4 E. | 614 | (DEADMA

1000

1 MILE

4000 5000 6000 7000 FEET

1 KILOMETER

AL 40 FEET
CAL DATUM OF 1929

ROAD CLASSIFICATION

Primary highway, all weather, hard surface

Light-duty road, all weather, improved surface

Secondary highway, all weather, hard surface

Unimproved road, fair or dry weather

Interstate Route | U. S. Route | State Route

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1952. Field check 1954

Polyconic projection. 1927 North American datum
10,000-foot grid based on South Dakota coordinate system, ... zone

GN MN
1°00′ 18 MILS
13° 231 MILS

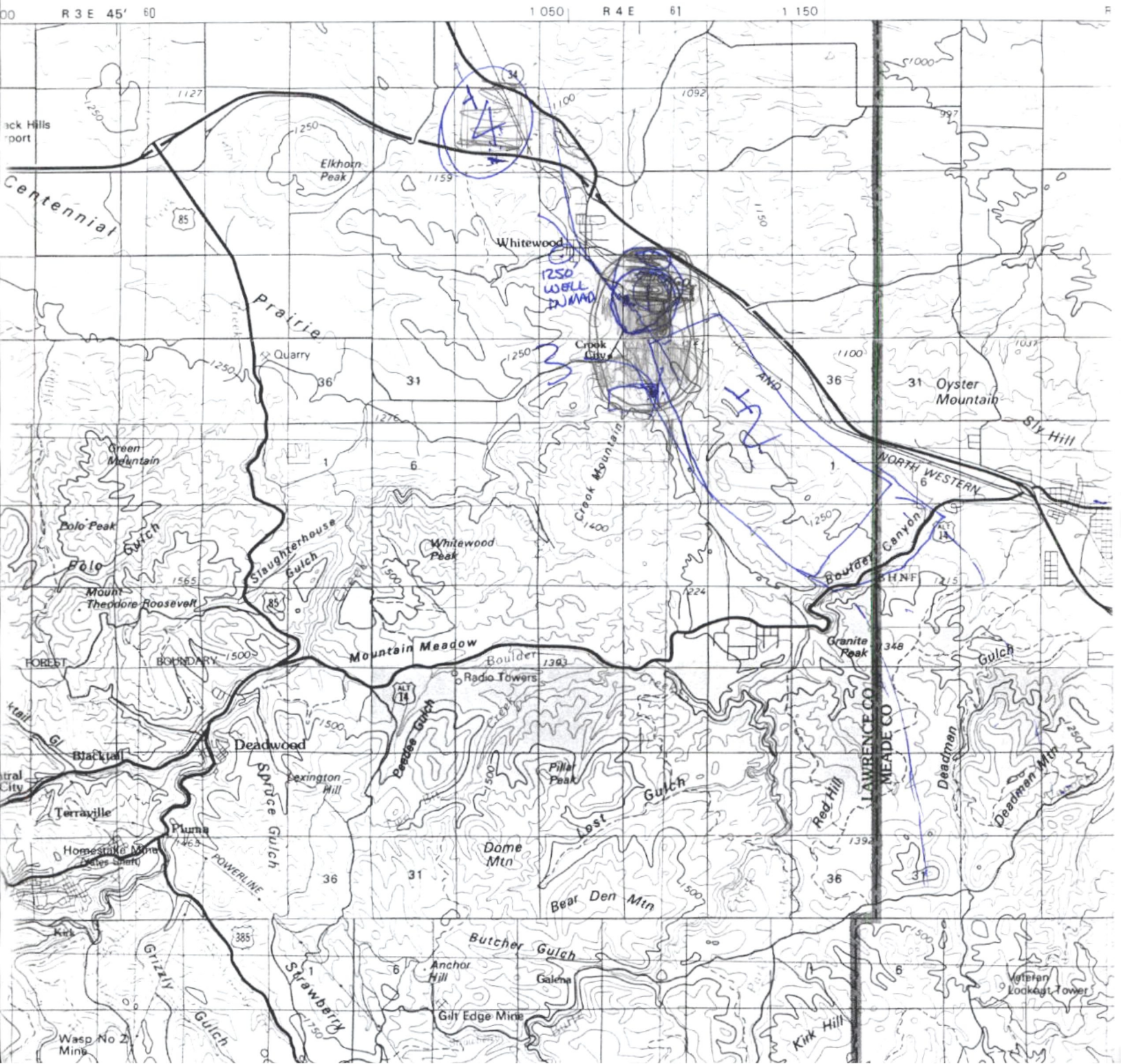
SCALE

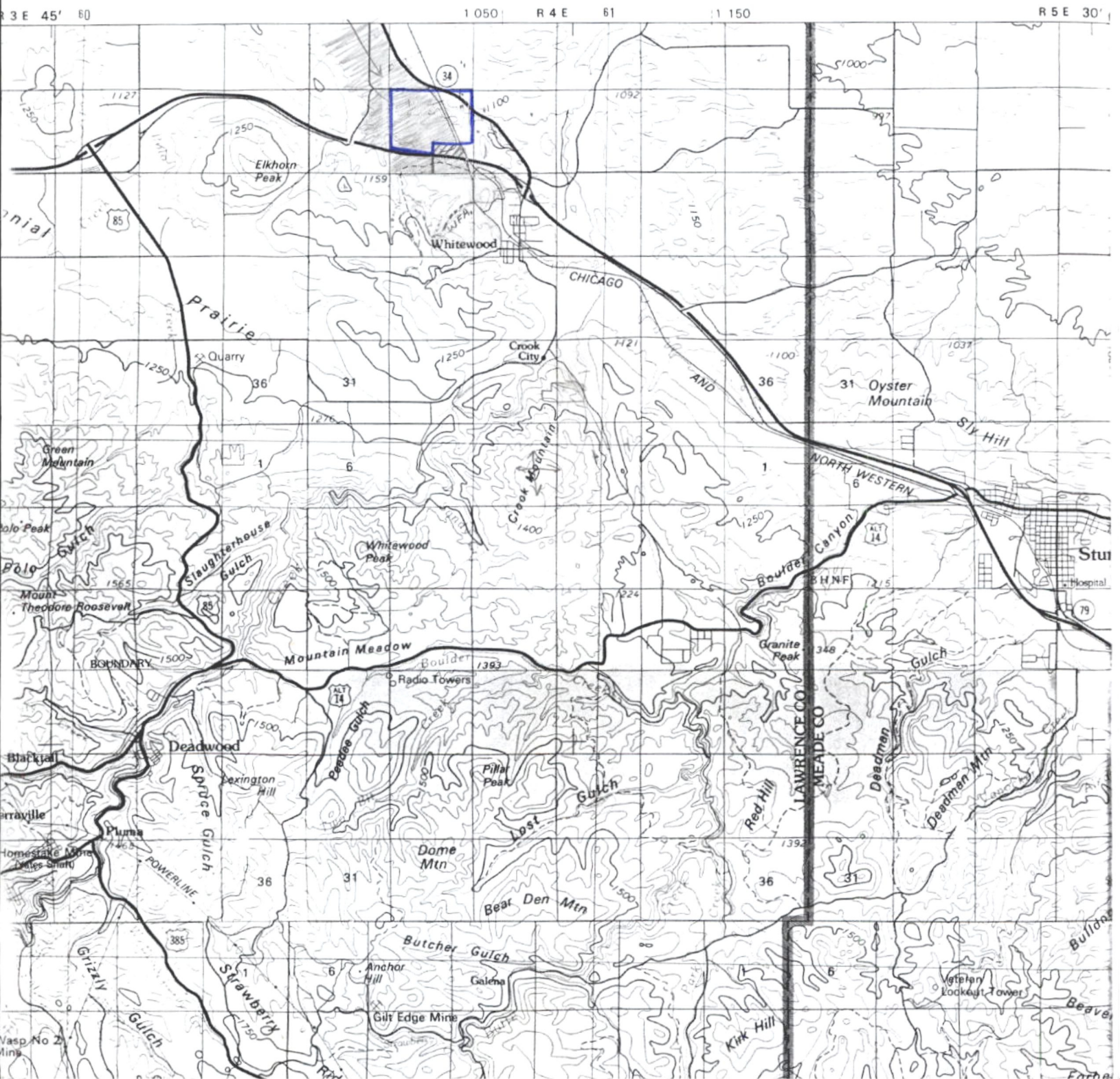
1 ½

1000 0 1000 2000

1 .5

CONTOUR IN


R 3 E 45' 60
1 050
R 4 E 61
1 150
Centennial
Prairie
Elkhorn Peak
Whitewood
1250 WELL DUMP
Crook City
Quarry
Oyster Mountain
Sly Hill
NORTH WESTERN
Green Mountain
Bolo Peak
Bolo Gulch
Slaughterhouse Gulch
Whitewood Peak
Crook Mountain
Boulder Canyon
Mount Theodore Roosevelt
FOREST BOUNDARY
Mountain Meadow
Boulder
Radio Towers
Granite Peak
Gulch
Deadwood
Blacktail
Spruce Gulch
Lexington Hill
Pilot Peak
Lost Gulch
Red Hill
LAWRENCE CO
MEADE CO
Deadman
Deadman Mtn
Terraville
Pluma
Homestake Mine
Dome Mtn
Bear Den Mtn
POWERLINE
Butcher Gulch
Anchor Hill
Galena
Gilt Edge Mine
Grizzly Gulch
Strawberry
Wasp No 2 Mine
Kirk Hill
Lookout Tower


R 3 E 45' 60
1 050
R 4 E 61
1 150
R 5 E 30'
Elkhorn Peak
Whitewood
CHICAGO AND NORTH WESTERN
Prairie
Quarry
Crook City
Oyster Mountain
Sly Hill
Green Mountain
Crook Mountain
Polo Peak
Polo Gulch
Slaughterhouse Gulch
Whitewood Peak
Boulder Canyon
Mount Theodore Roosevelt
BHNF
Granite Peak
Gulch
BOUNDARY
Mountain Meadow
Boulder
Radio Towers
Deadwood
Blacktail
Spruce Gulch
Lexington Hill
Paddock Gulch
Pillar Peak
Lost Gulch
Red Hill
LAWRENCE CO
MEADE CO
Deadman
Deadman Mtn
Pluma
Homestake Mining Co. (Yates Shaft)
POWERLINE
Dome Mtn
Bear Den Mtn
Butcher Gulch
Grizzly Gulch
Strawberry
Anchor Hill
Galena
Gilt Edge Mine
Kirk Hill
Lookout Tower
Beaver
Wasp No 2 Mine
Hospital

BY
FEDERAL EXPRESS

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155 South Madison Street, Suite 302
Denver, Colorado 80209-3014
(303) 399-9630 FAX (303) 399-9701

Dec 19, 1989

Mr Jerry Boyer
Brohm Mining Corporation

Please find enclosed the hard copy version of Adrian Browns Decembr 4 presentation in Denver.
Should you have any questions please do not hesitate to call.

Stephanie Brown
Librarian

BROHM MINING CORPORATION

GILT EDGE EXPANSION PROJECT

POSITION STATEMENT

GROUNDWATER HYDROLOGY

Presented by

Adrian Brown

Adrian Brown Consultants, Inc.

Denver, Colorado

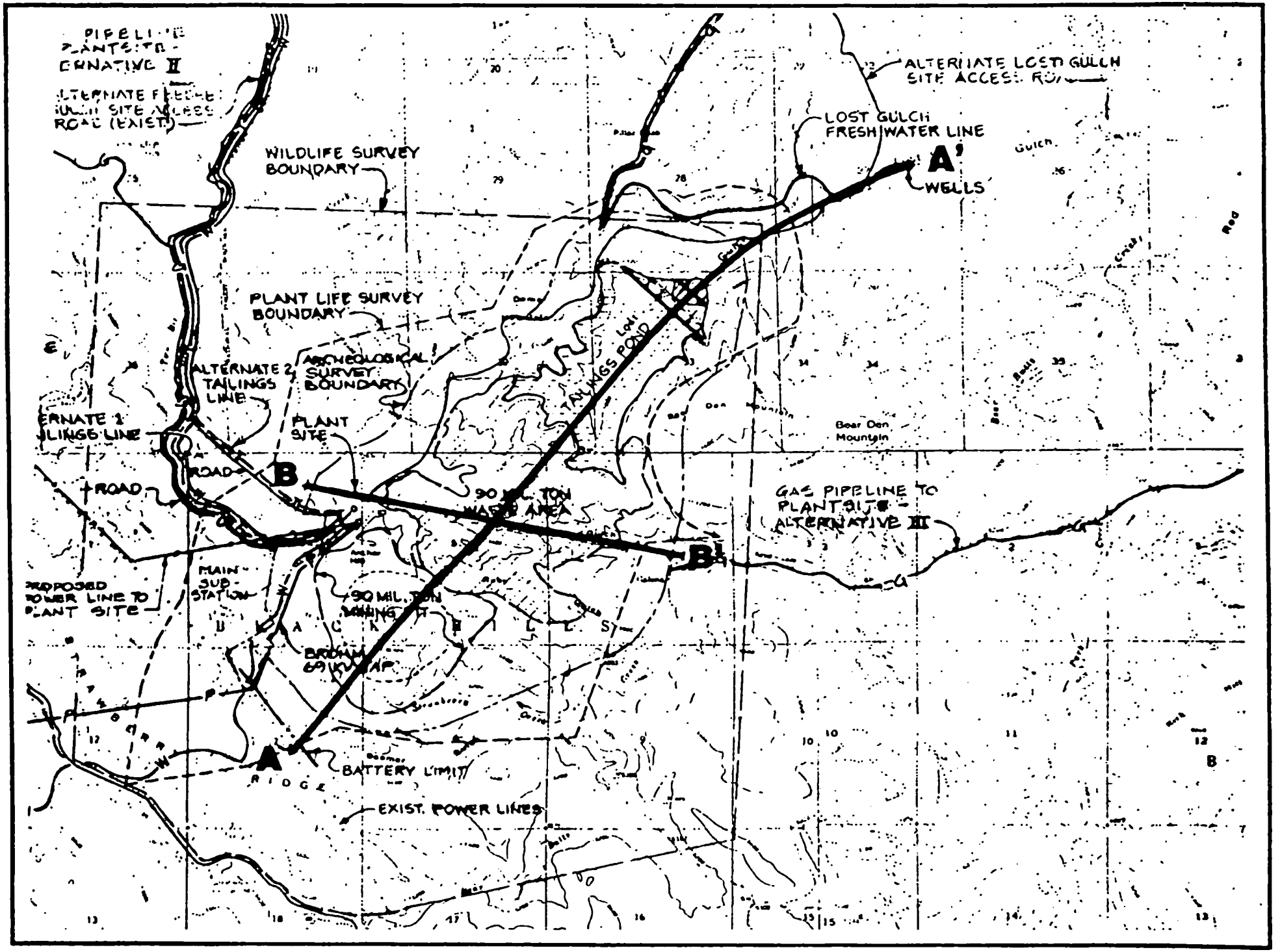
December 4, 1989

GILT EDGE EXPANSION PROJECT

- Black Hills
- Sulfide Gold Project
- 325 million tons of rock
- 90 million tons ore
- Mine, mill, cyanide extraction

PROJECT ELEMENTS

- Open Pit
  - 250 acres
  - 1,300 feet deep
  - 4,000 feet across
  - Flooded at end of project
- Waste rock pile
  - 600 acres
  - 300 feet thick
  - reclaimed
- Tailings disposal area
  - engineered
  - 300 acres
  - 600 feet thick
  - drained and reclaimed


PIPELINE PLANTSITE - ERNATIVE II
ALTERNATE FRESH WATER GULCH SITE ACCESS ROAD (EXIST.)
WILDLIFE SURVEY BOUNDARY
PLANT LIFE SURVEY BOUNDARY
ALTERNATE 2 TAILINGS LINE
ARCHEOLOGICAL SURVEY BOUNDARY
ERNATE 1 LINGS LINE
PLANT SITE
TAILINGS POND
ROAD
ROAD
B
B'
90 MIL. TON WASTE AREA
MAIN SUB-STATION
PROPOSED POWER LINE TO PLANT SITE
90 MIL. TON MINING
BROWN 69 IN MAP
A
RIDGE
BATTERY LIMIT
EXIST. POWER LINES
ALTERNATE LOST GULCH SITE ACCESS RO
LOST GULCH FRESH WATER LINE
A'
WELLS
Bear Den Mountain
GAS PIPELINE TO PLANTSITE - ALTERNATIVE III

HYDROLOGY ISSUES

Operational issues:

- impact of development on groundwater recharge
- impact of dewatering of mine
- impact of development on stream flow and quality
- impact of water supply to mine on Madison aquifer

Reclamation issues

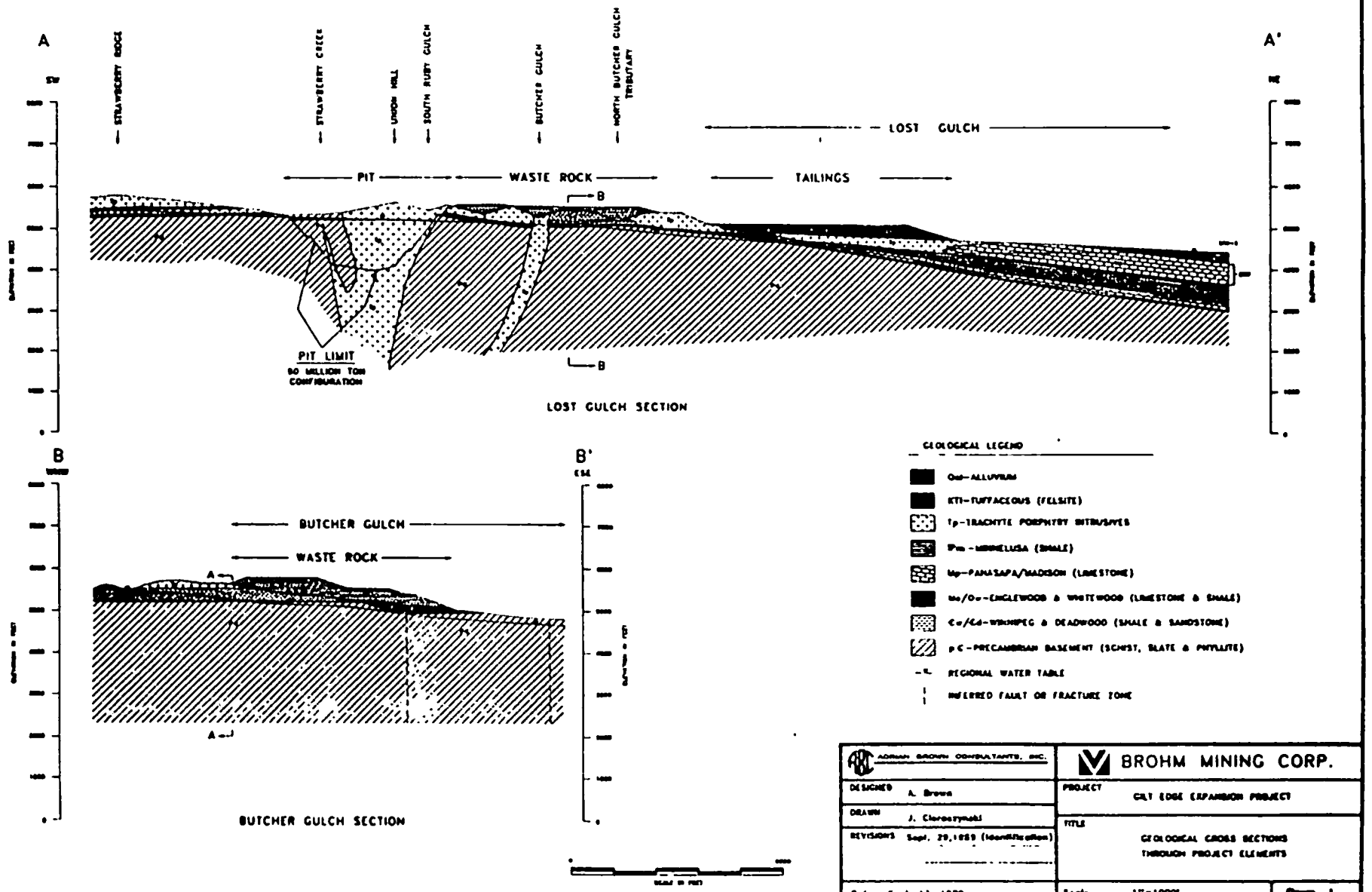
- quality of water in pit
- impact of flow from pit
- impact of waste rock seepage
- impact of tailings impoundment discharge
- impact of tailings impoundment seepage
- impact of runoff from reclaimed surfaces

PROJECT AREA

- South Dakota
- Black Hills
- hilly, wooded terrain
- about 6,000 feet above sea level
- steep valleys drain generally east
- 27 inches of precipitation per year
- half falls as snow
- lake evaporation about 30 inches per year

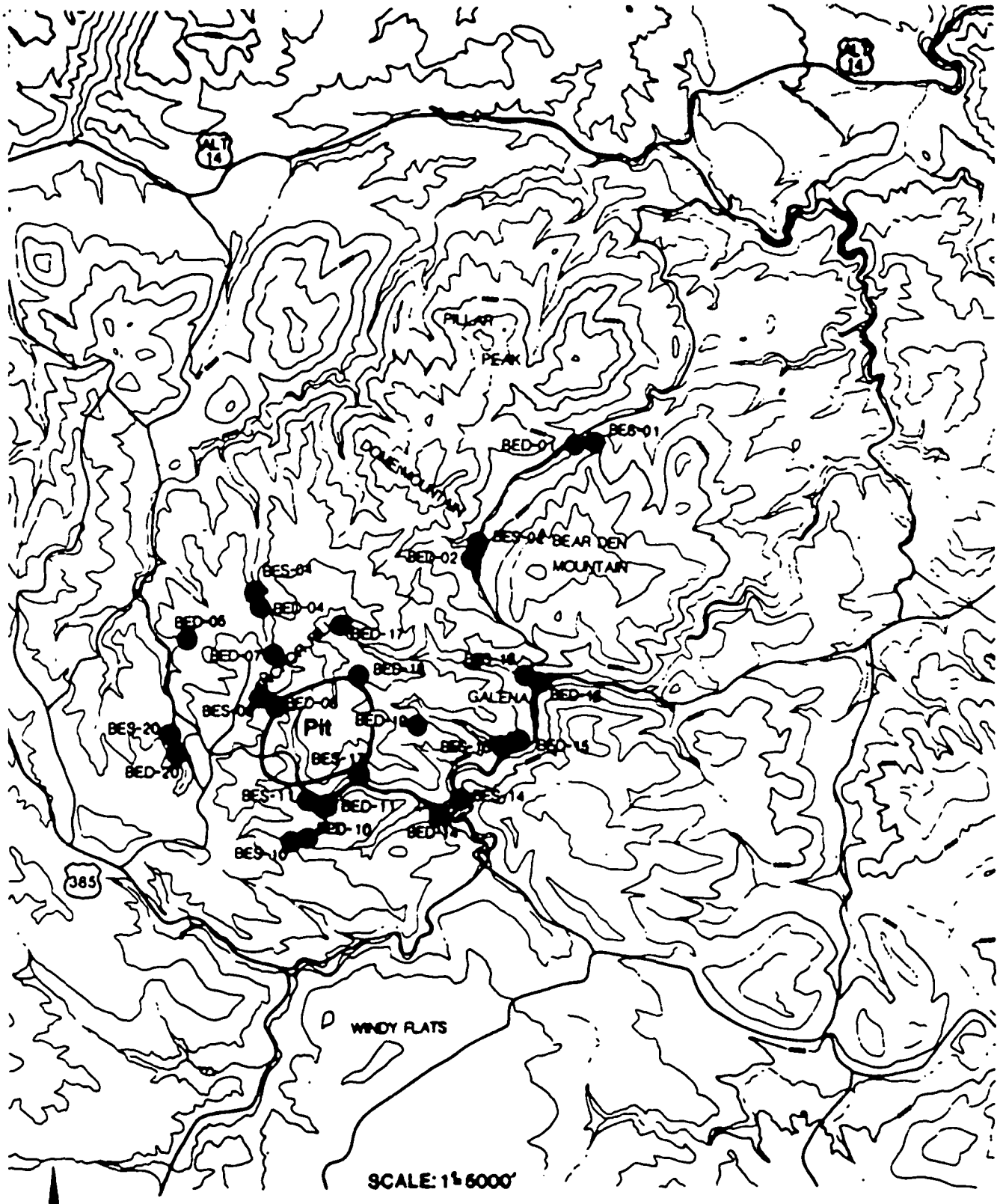
GEOLOGY

- basement: precambrian gneisses and schists
- overlain by younger sediments
    - miocene through eocene age
    - alluvial material in the local valleys
- east of the project area
    - Madison formation
        - major regional aquifer
        - 2,000 feet deep at Sturgis
- orebody
    - intruded volcanic rocks
        - plugs, sills, and dikes


A
A'
STRAWBERRY RIDGE
STRAWBERRY CREEK
UNION HILL
SOUTH RUBY GULCH
BUTCHER GULCH
NORTH BUTCHER GULCH TRIBUTARY
LOST GULCH
PIT
WASTE ROCK
TAILINGS
B
B
PIT LIMIT
90 MILLION TON CONFIGURATION
LOST GULCH SECTION
B
B'
BUTCHER GULCH
WASTE ROCK
A
A
BUTCHER GULCH SECTION
GEOLOGICAL LEGEND
Qal–ALLUVIUM
KTt–TUFFACEOUS (FELSITE)
Tp–TRACHYTE PORPHYRY INTRUSIVES
Pm–MINNELUSA (SHALE)
Mp–PAHASAPA/MADISON (LIMESTONE)
Mw/Do–CHEYENNE & WHITEWOOD (LIMESTONE & SHALE)
Cw/Cd–WINNIPEG & DEADWOOD (SHALE & SANDSTONE)
pC–PRECAMBRIAN BASEMENT (SCHIST, SLATE & PHYLLITE)
REGIONAL WATER TABLE
INFERRED FAULT OR FRACTURE ZONE
ADRIAN BROWN CONSULTANTS, INC.
BROHM MINING CORP.
DESIGNED A. Brown
DRAWN J. Clarenzynski
REVISIONS Sept. 29,1989 (Identification)
PROJECT GOLD EDGE EXPANSION PROJECT
TITLE GEOLOGICAL CROSS SECTIONS THROUGH PROJECT ELEMENTS
Date: Sept. 13, 1989
Scale 1"=1000'
Figure 1

GEOHYDROLOGY

- Site:
  - moderate to low hydraulic conductivity
  - little groundwater flow
  - groundwater resources very limited
  - upper 100 feet:
    - higher permeability
    - groundwater quality poor
    - water table near ground surface
    - downward gradient
    - about 3 inches/year infiltration
  - deeper rock
    - well water level about 200 feet
    - water quality improves with depth
    - lateral gradient high



Ecotech

Denver, Colorado

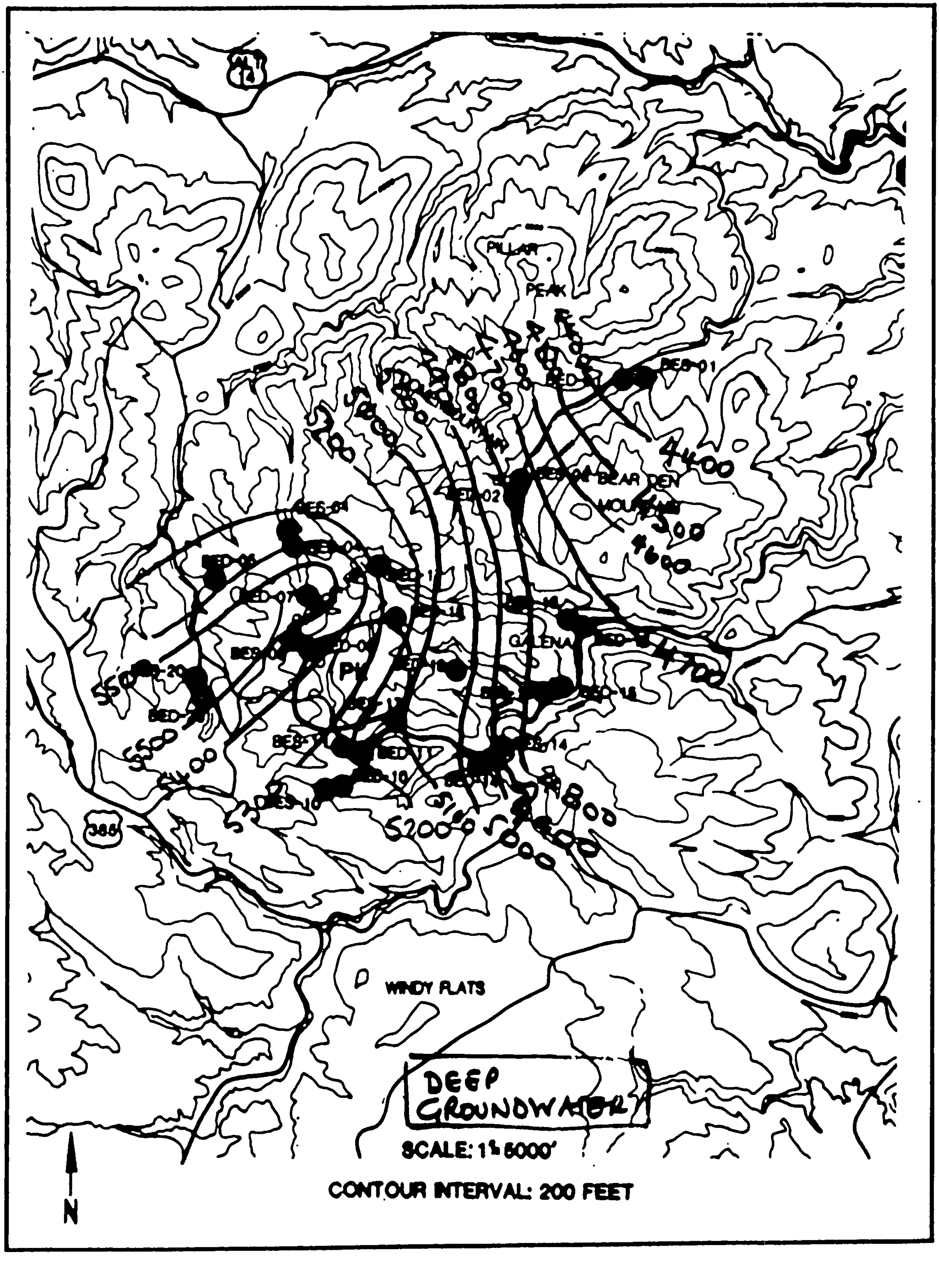
BROHM MINING CORP.

SULFIDE PROJECT
GROUND WATER MONITORING SITES

Project

GILT EDGE PROJECT

File No.: 189-006-56 Date: NOVEMBER, 1988 Figure No.: 1



SCALE: 1"= 6000'

CONTOUR INTERVAL: 200 FEET

GEOHYDROLOGY (continued)

- Regional:
  - younger sediments thicken to east
  - limestone, dolomite, sandstone aquifers
  - Madison, Minnelusa, and Inyan Kara
  - recharged by infiltration
    - outcrop areas
    - vertical leakage
  - head gradient small to north east

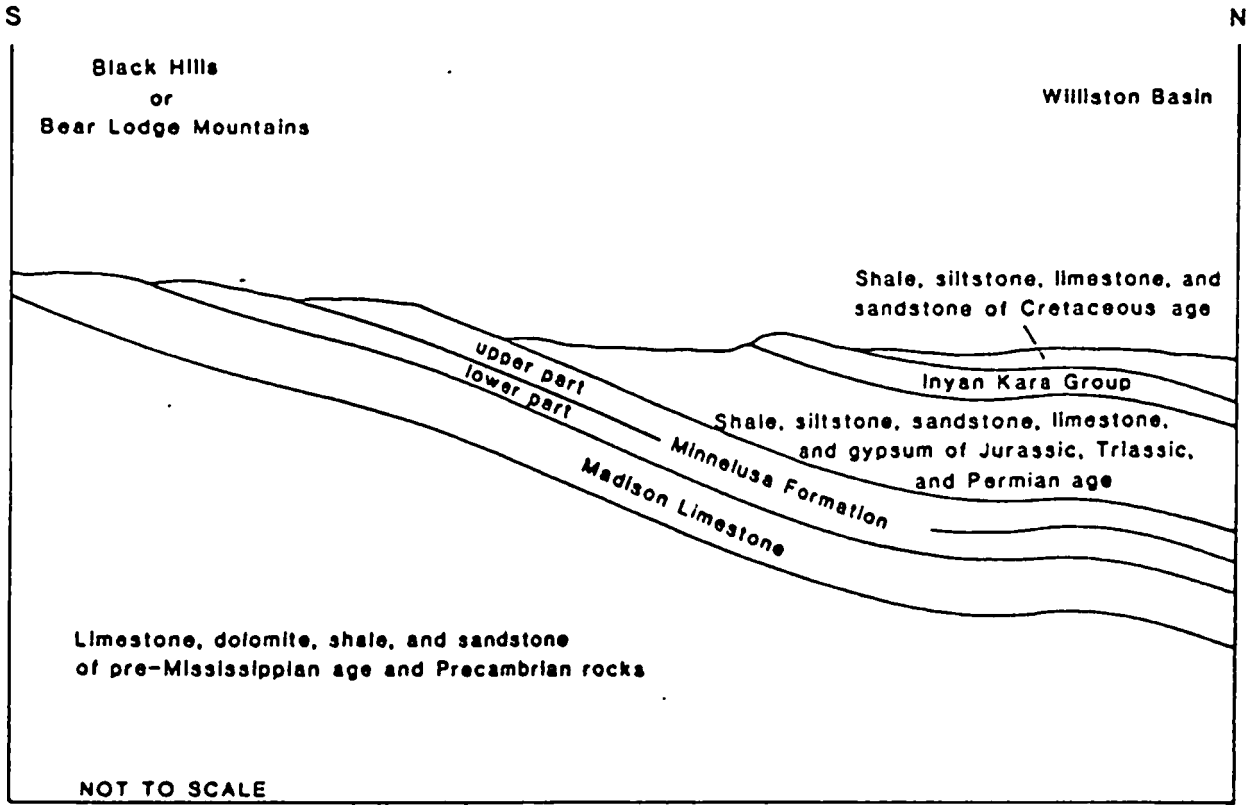


Figure 5.--Generalized geologic section.

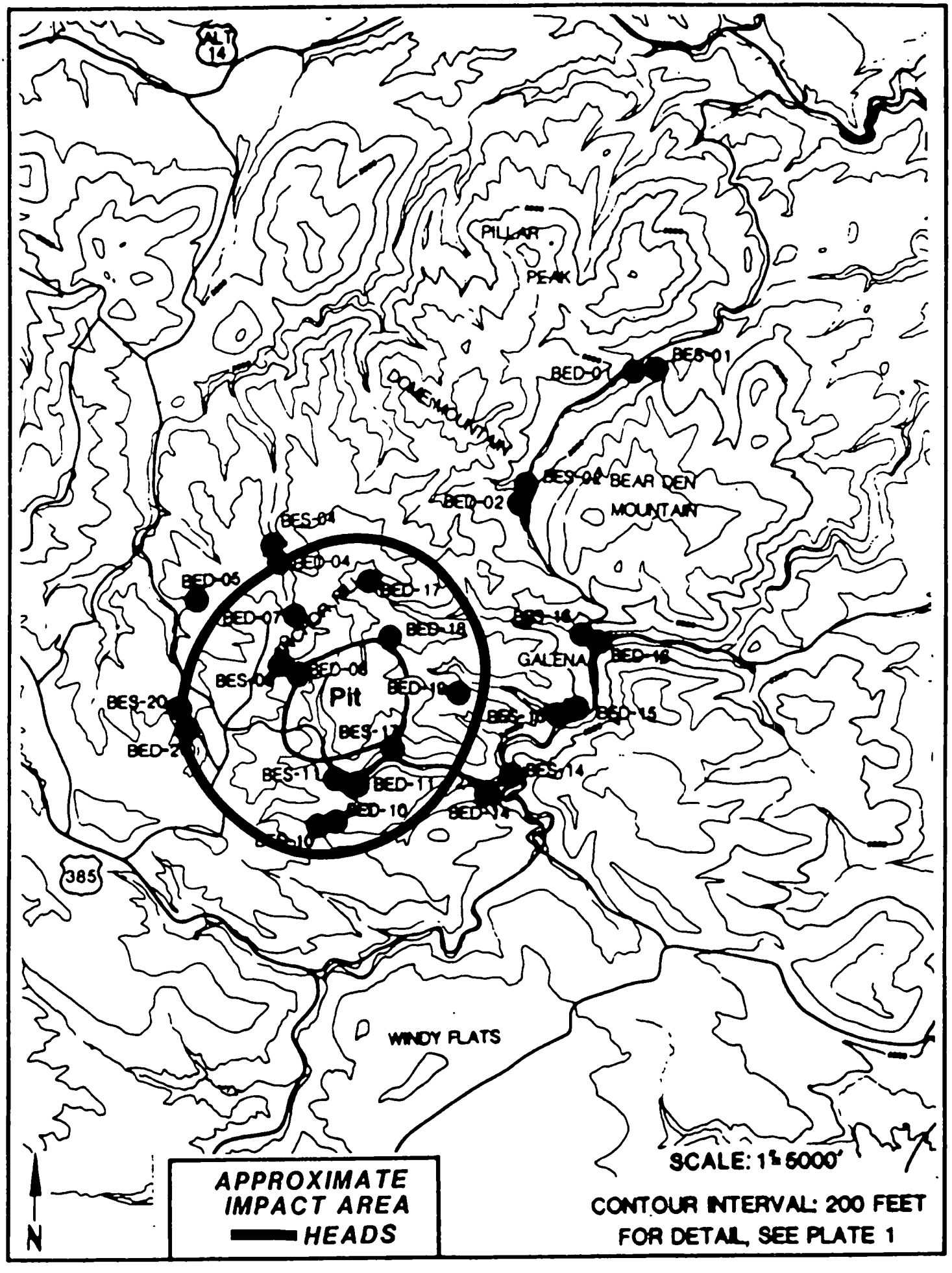
SURFACE HYDROLOGY

- System:
  - Cheyenne River Basin
    - Belle Fourche River
      - Bear Butte Creek
        - Strawberry Gulch
        - Ruby and Butcher Gulch
        - Lost Gulch
- Flow:
  - gulches ephemeral
  - creeks and rivers perennial
  - surface water production 100 gpm/sq.mi.
- Quality:
  - quality presently poor
    - natural
    - AMD

IMPACTS OF PIT ON GROUNDWATER USERS

- Flow to pit:
  - peak 500 gpm
  - long term 200 gpm
- Impact:
  - drawdown to < one mile
  - low permeability
  - infiltration
- Other well users
  - no water well users within one mile
  - nearest well at Galena
    - tap Bear Butte Creek
    - not affected
- Springs
  -

expected to be minor
  - strong downward gradient
  - little change due to pit
- Aquifers
  - no impact
  - recharge reduced by 200 gpm
  - negligible


ALT 14
PILLAR PEAK
DOME MOUNTAIN
BED-01
BES-01
BES-02
BEAR DEN MOUNTAIN
BED-02
BES-04
BED-04
BED-05
BED-17
BED-07
BED-18
BES-16
GALENA
BED-16
BES-08
BED-08
Pit
BED-19
BES-20
BED-15
BES-12
BED-12
BES-14
BES-11
BED-11
BED-10
385
WINDY FLATS
N
APPROXIMATE IMPACT AREA
HEADS
SCALE: 1" = 5000'
CONTOUR INTERVAL: 200 FEET
FOR DETAIL, SEE PLATE 1

IMPACT ON STREAM FLOW

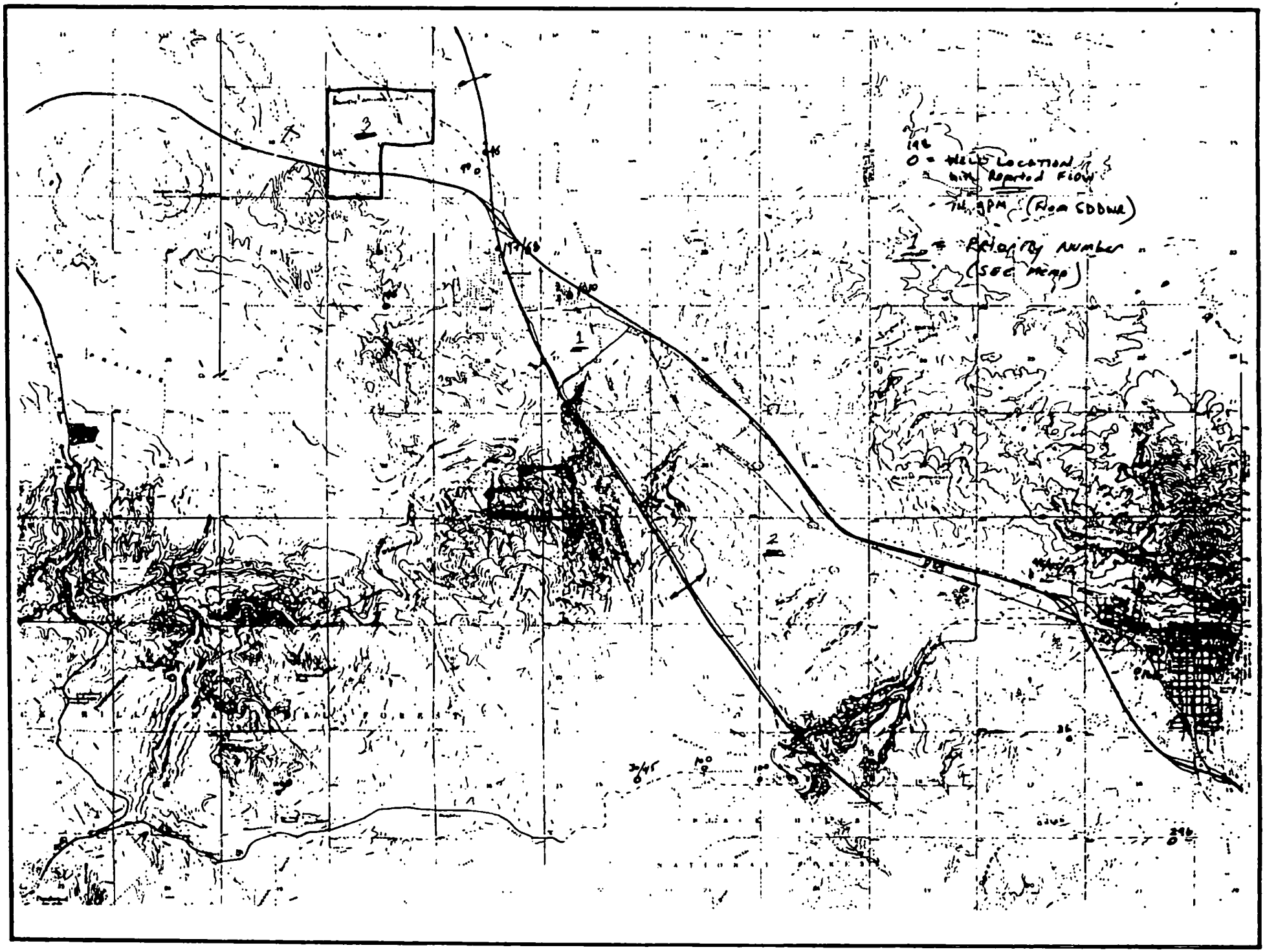
- Pit:
  - intercept Strawberry Creek
  - divert infiltration
  - 300 gpm max (500 AFY)
- Tailings and Waste Rock
  - reduction of 150 gpm (250 AFY)
  - Ruby, Butcher, Lost Gulch
  - not significant impact
- Bear Butte Creek
  - total impact
  - 750 AFY
  - Sturgis 15,000 AFY
  - minor impact
- Quality
  - improved
    - no AMD
    - reduced turbidity

IMPACT OF WATER SUPPLY ON MADISON

- Requirements:

Years	Flow rate	Volume	Use
0 - 2	2,000 gpm	6,500 acre feet	Start-up
2 - 20	500 gpm	14,500 acre feet	Make up water
20 - 30	3,300 gpm	55,000 acre feet	Filling pit

- Source
  - wells in Madison formation
  - near Whitewood
  - 4-6 wells proposed
  - seven mile pipeline
  - resource relocation
  - impact on Madison minimal
    - <200 feet drawdown
    - depth to water 1,200 feet
    - <10 miles radius
    - 6 other wells
    - Madison Aquifer large
      - 270,000 square miles
      - 2,000 feet thick
      - billion acre feet
      - renewable resource


O = WELL LOCATION WITH REPORTED FLOW
74 GPM (FROM CDDWR)
1 = PRIORITY NUMBER (SEE MAP)

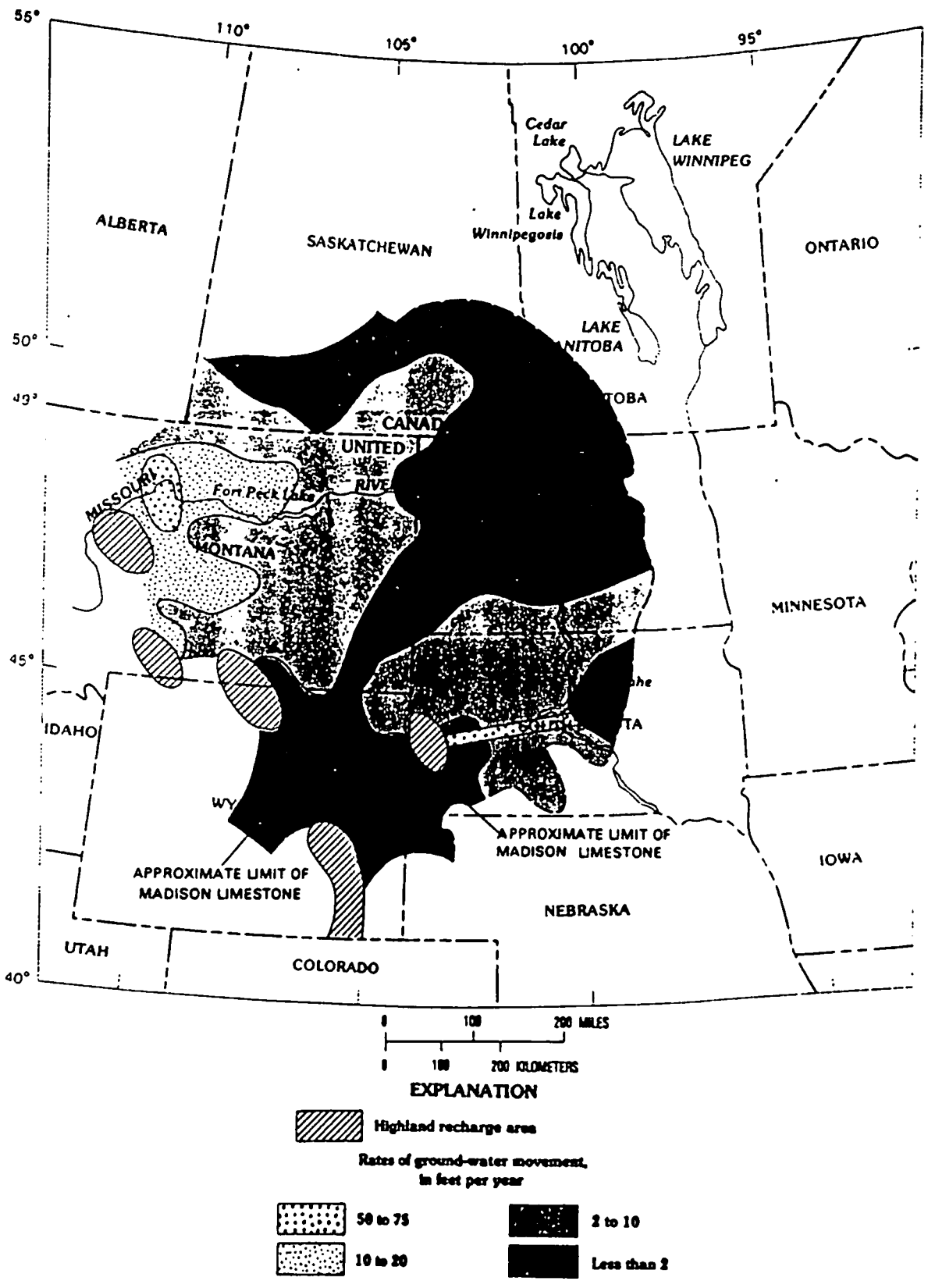
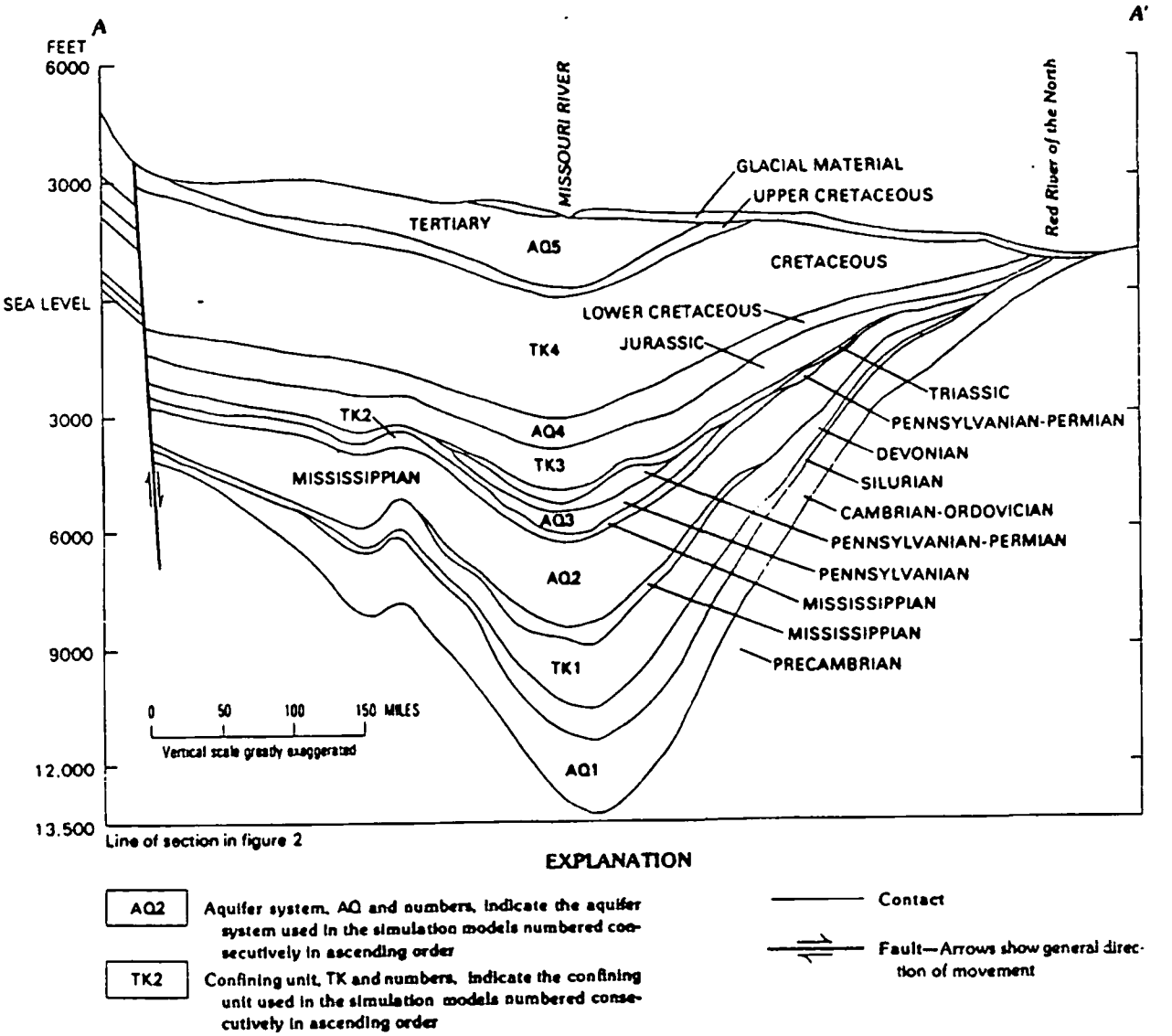


FIGURE 43.—Calculated rates of ground-water movement in the Mississippian aquifer system (including the Madison Limestone), study area and adjacent parts of Canada.



EXPLANATION

AQ2 — Aquifer system, AQ and numbers, indicate the aquifer system used in the simulation models numbered consecutively in ascending order

TK2 — Confining unit, TK and numbers, indicate the confining unit used in the simulation models numbered consecutively in ascending order

Contact

Fault—Arrows show general direction of movement

FIGURE 4.—Generalized geohydrologic section showing relationship of aquifers and confining layers from a ground-water recharge area in Montana to a discharge area in North Dakota.

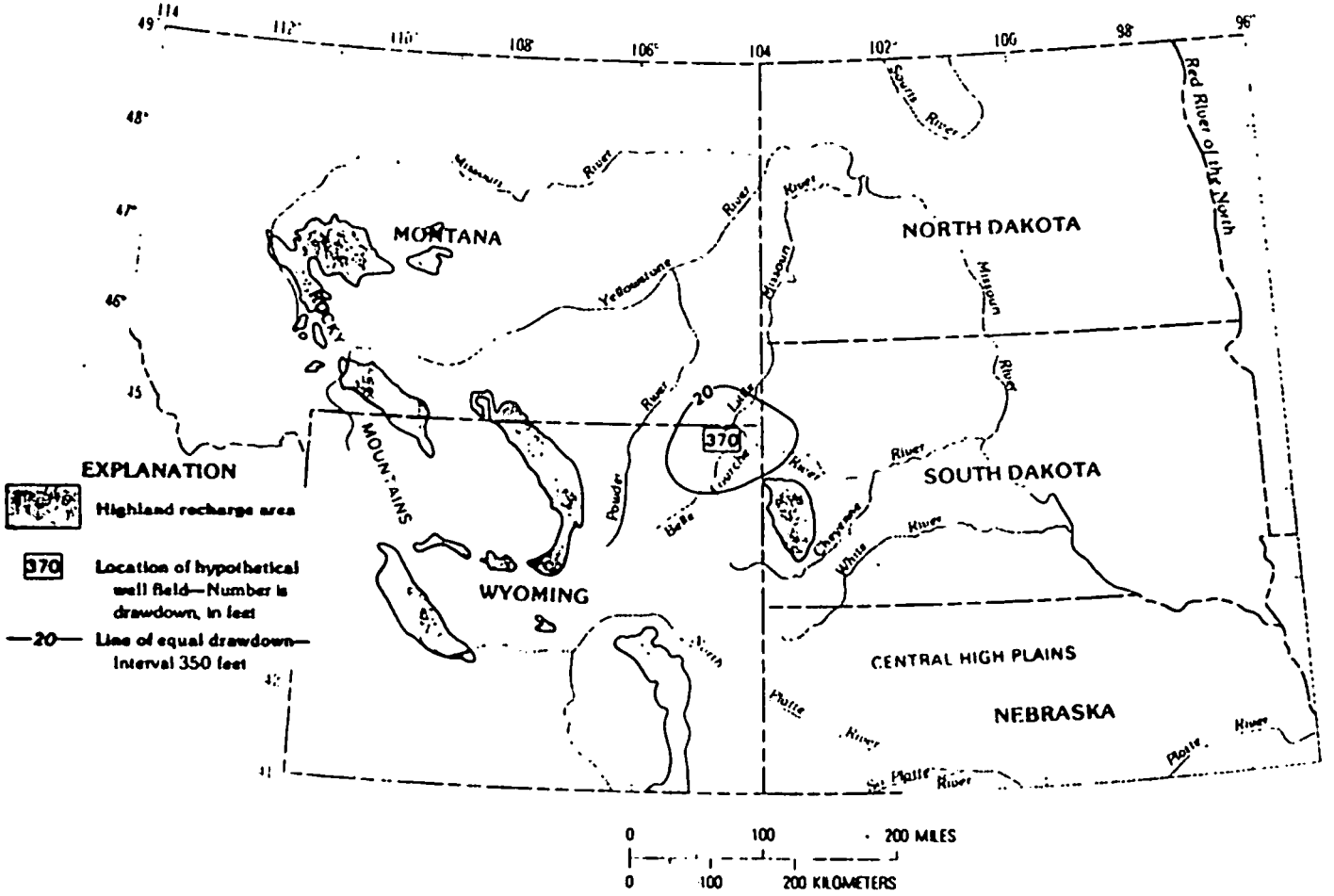
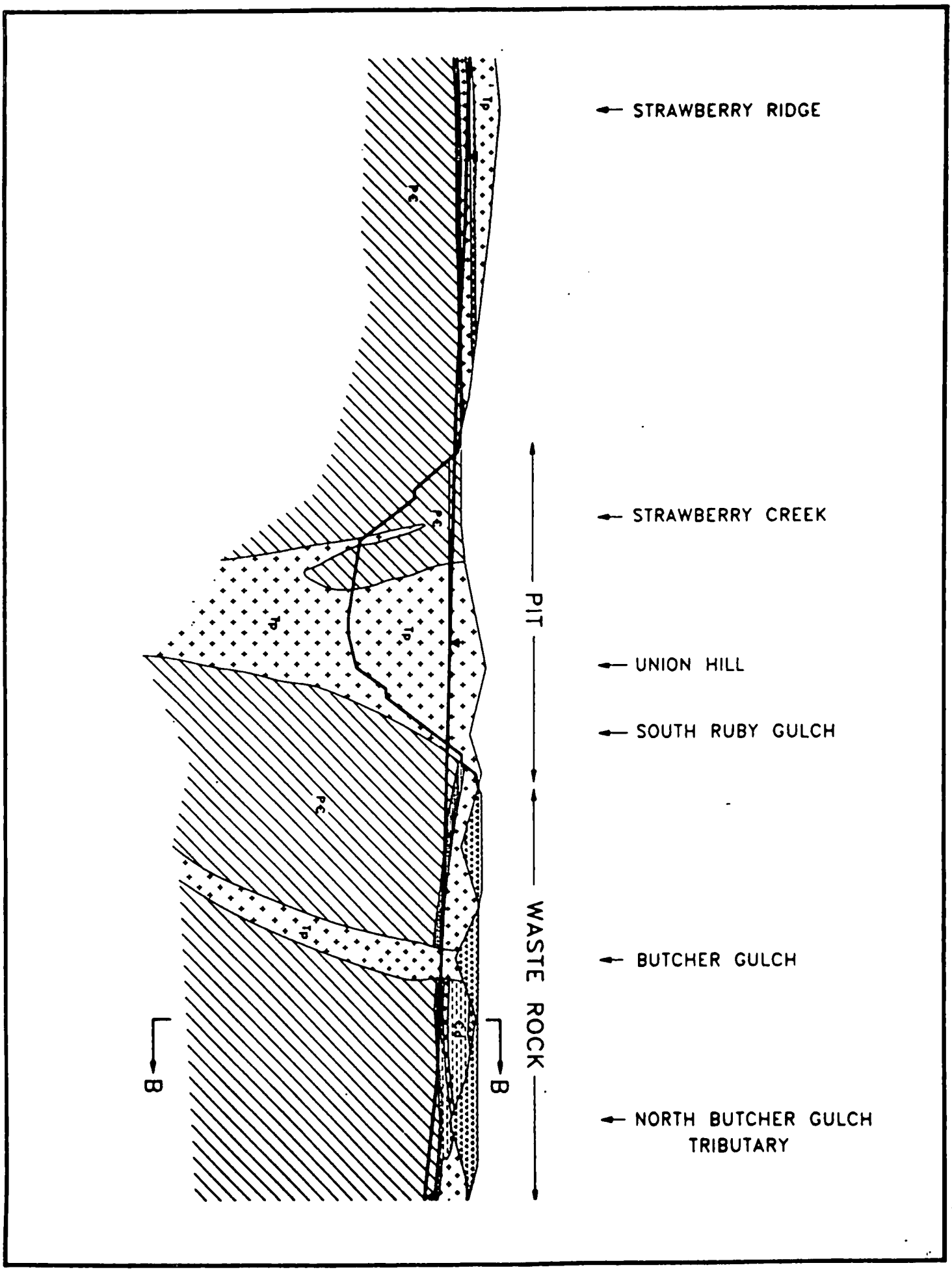


FIGURE 48.—Calculated drawdown in the Mississippian aquifer system after 5.9 years of hypothetical pumping at a rate of 27.9 cubic feet per second and an assumed storage coefficient of 2.0×10^{-4}.

RECLAIMED PIT IMPACTS

- Filling with Madison water
  - excellent quality
  - somewhat alkaline
  - deep
- Impact of AMD on pit wall
  - flooded as pit fills
  - neutralized by fill water
  - very large chemical buffer
  - remaining exposed pit wall:
    - burn out
    - neutralized in pool
- Outflow:
  - exit point south rim
  - Strawberry Creek @ 5220 feet
  - net groundwater inflow
  - estimated at 100 gpm
  - about present flow
  - turnover time = 300 years
- Quality:
  - excellent
  - constant

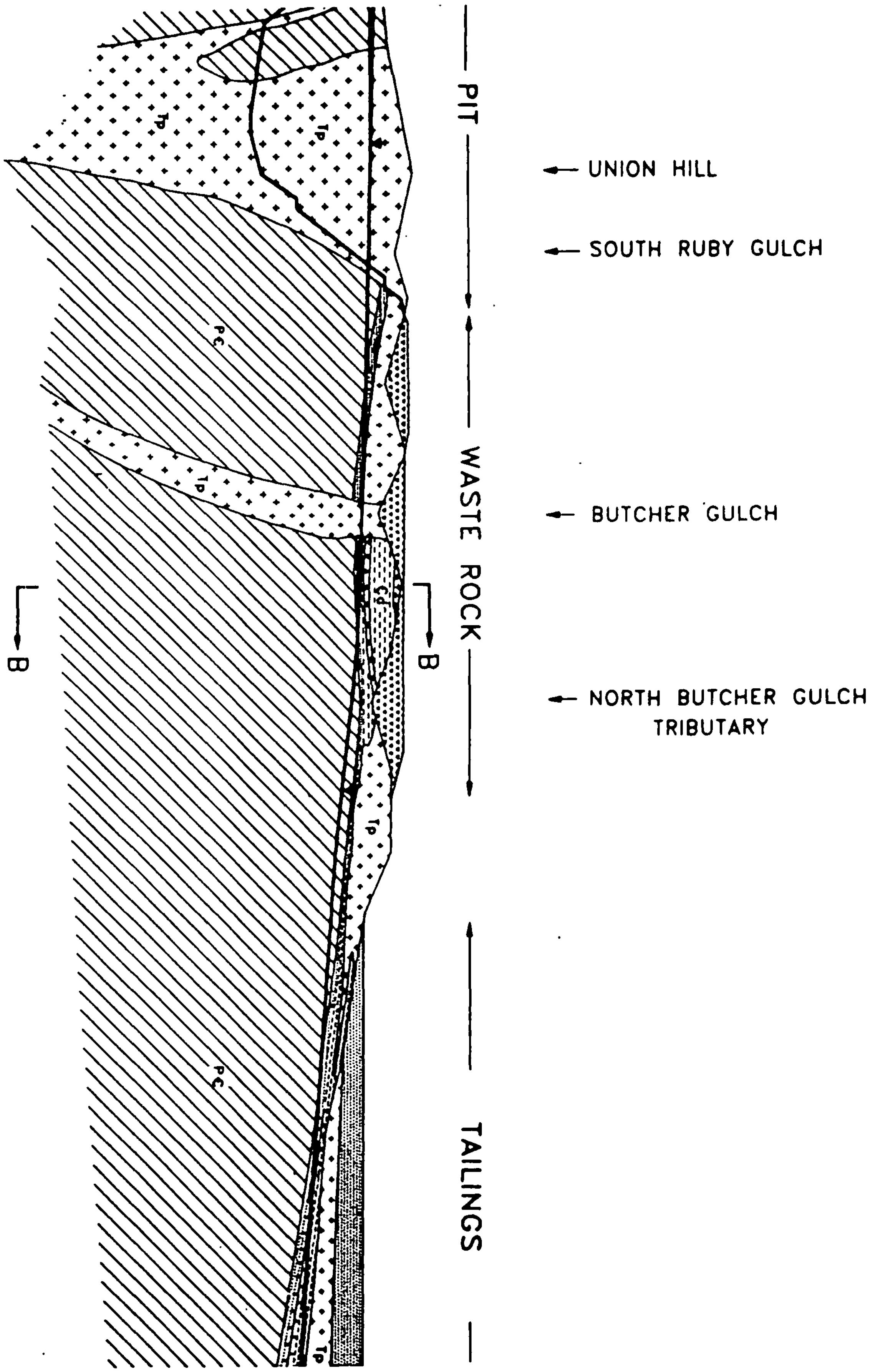

STRAWBERRY RIDGE
STRAWBERRY CREEK
UNION HILL
SOUTH RUBY GULCH
BUTCHER GULCH
NORTH BUTCHER GULCH TRIBUTARY
PIT
WASTE ROCK
B
B
Tp
Pc
Tp
Pc
Tp
Tp
Pc
Tp
Gd

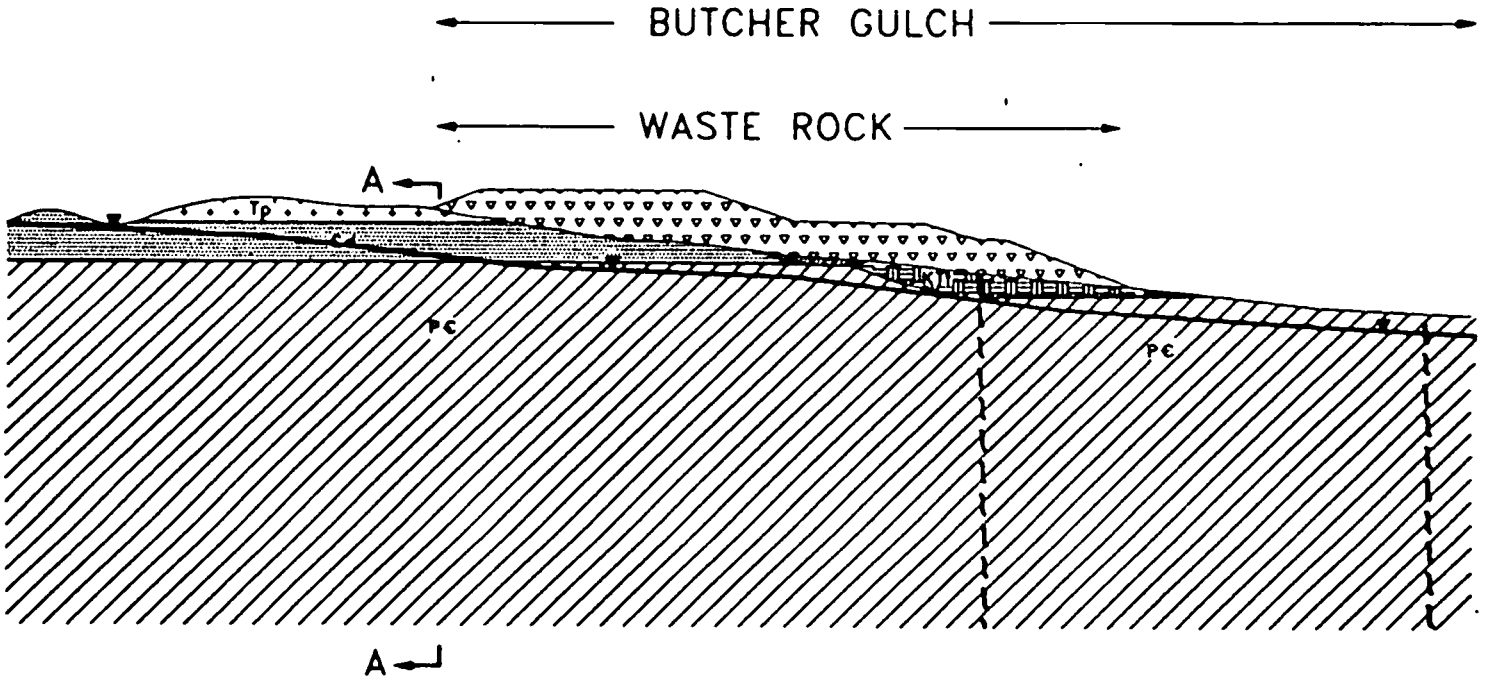
RECLAIMED PIT IMPACTS (continued)

- Other options:
  - continued dewatering
  - natural flooding
  - backfilling

WASTE ROCK DISPOSAL AREA IMPACTS

- Minimize AMD:
  - minimize flow pathways
    - air
    - water
  - possibly add alkaline materials
  - progressive reclamation
    - shaping and grading
    - minimize infiltration, maximize runoff
  - progressive revegetation
- Drainage:
  - some expected
  - <40 gpm
  - collected at the base of the pile
  - passive treatment
  - seepage joins deeper groundwater
- AMD:
  - sulfide minerals, water, and oxygen available
  - limited by oxygen
    - initial oxygen rapidly depleted
    - groundwater oxygen negligible
    - circulation will be eliminated by design

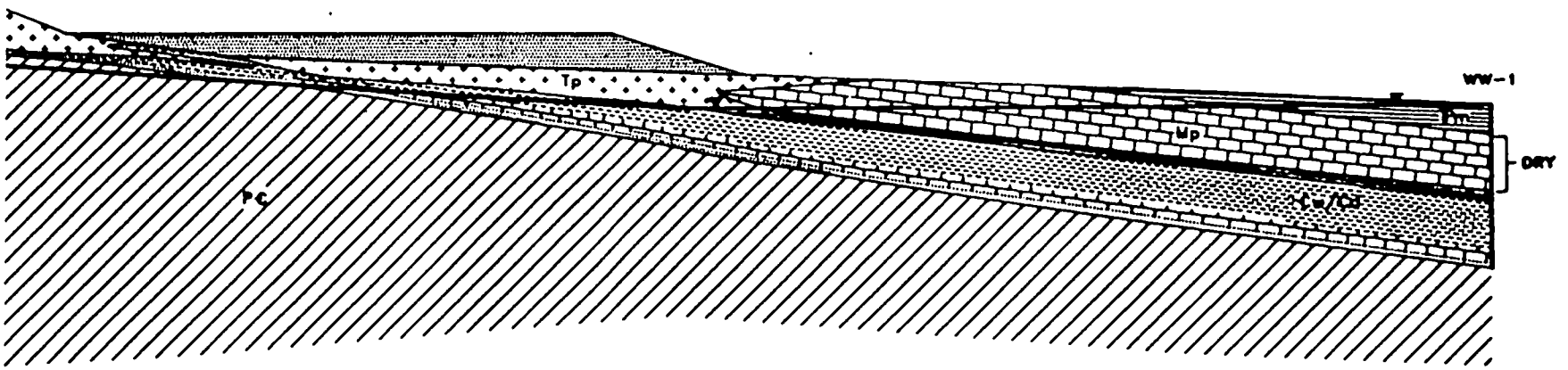

PIT
WASTE ROCK
TAILINGS
UNION HILL
SOUTH RUBY GULCH
BUTCHER GULCH
NORTH BUTCHER GULCH
TRIBUTARY
B
B
Tp
pC



BUTCHER GULCH SECTION

TAILINGS IMPACT

- Design
  - maximizes consolidation/drainage
  - minimizes seepage
  - minimizes permeability
  - maximizes leachate collection
- Reclamation
  - shaping and reclaiming of the surface
  - plant growth
  - minimize infiltration (<10 gpm)
  - maximize runoff
  - passive treatment system
- Seepage
  - essentially eliminated
  - cyanide decays
  - soil/rock improves quality naturally
  - long path length
  - no impact expected


LOST GULCH
TAILINGS
Tp
Mp
Pc
WW-1
DRY

MEETING W/ STEVE CHRISTENSEN
(D. Langford too)

11/2/89

PRUSSIAN & HATTIE

1890

- County acquired through Thusnulda Mining & successors
- 6.42 Ac.
- 1978 - (mid-late 70's Development in Lawrence County)
  Grays got acreage
- ★ — Need to know who has been paying taxes
- — Steve will investigate & Recommend procedure
- — Quiet title action is last thing we want to do — (from Mike)

TAX ISSUE

- No CN Tax - Reporting Mech. not set up (Dept of Rev. unhappy)
- Attaching personal property as real property
- Arrange Meeting
- Get position paper to Steve - Dick will do

WATER

- LANCE TO ARRANGE MEETING W/ TIPPEY
- $5000 TO STRAIGHTEN OUT "CORNER" ISSUE ON WILSON
- ★ — DO WE WANT to go Ahead. & RESOLVE / NOT UNTIL EASEMENTS ARE ALL IN.
- C.U. — enjoyment, prop. values, deter imp.
- Phoned Rita Nowast while in Steve's office
  Talked to 5 brothers & sisters - said talk to dad - he'll understand & is not senile; Talk to him @ Cafe, not necessary for others to be there - Brothers & Sisters Against idea
  Talked w/ Charlie - says NO

BIG BROTHERS/BIG SISTERS - STEVE'S YOUNGER BROTHER/TODD WOULD BE PROBABLY GOOD IDEA

MEETING W/ STEVE CHRISTENSEN 10/17/89

① Tim Johnsen - '
② WATER
③ Quiet Title

EASEMENTS - Steve's rec. is to go for easements now & get individuals signed ASAP.

WATER

SEC. 27 / Lance to contact Lester Tippy (SW 1/4 + 68 AC. IN W 1/2 NE)
Wilson & Tippy are key individuals
August Nonact - 90 yrs old, son Gene - logger, lives on prop. (Steve very knowledgable of family
Is Wilson deadable. (Frank - sec. 39)
Tom F. Thompson - Bad News NE/NE but across tracks
Alvin Rapp SE/NE

EASEMENT - Steve to contact Jeff Bloomberg & then meet w/ Bloomberg w/ sympathetic C. Commissioner

County Easements - Crossing interstate & railroad - for what acreage & whether assignable

Lawrence County P&Z - Charles Wennberg

LAND

MEETING W/ STEVE CHRISTENSEN
LANCE HUBBARD
MIKE NEUMANN
JIM BARRON

10/18/89

DISCUSSION OF LAND ACQUISITION STRATEGY FOR WATER EVALUATION

- Whitewood P&Z need not be involved in initial discussion

- Railroad (Chicago & Northwestern R.R.) ownership being determined.

- Procedure with Tippey, Nonast, & Wilson
  Both LANCE & STEVE to meet with all

- Timing - Speak first with Nonast and Tippey, then Wilson
  Contact - initiate this coming weekend (Saturday 21, October)

Consideration - $2500/well site
$2500 for easement

EnecoTech

F A C S I M I L E
(303) 293-2735

DATE: 10-12-89 TIME: 840 (a.m.) or _____ p.m.

TO: Brown
Jim Barron

PRIORITY: Normal
Urgent

~~Phone~~: FAX 605-578-1709

FROM:

Project: Lost Gulch

Please call (303) 293-2703 if you do not receive the number of pages listed below or if you have a problem.

Number of Pages (Including Cover Sheet): 13

COMMENTS: Jim - I just need to get John approval and will send final copies (4) of reports this week

5.0 SITE HYDROGEOLOGY

Three potential regional aquifer zones were present in the Lost Gulch area. Historically the Minnulesa, Madison (Pahasapa) and Deadwood formations produce water through much of the Black Hills. Permeable zones in the formations are associated with sandy layers and solution voids and fractures within the limestones and dolomites. Target depths for the test well were based upon the estimated depths to the Minnulesa, Madison and Deadwood formations.

Ground water was first encountered in a sandstone in the Minnulesa formations at 39 feet below ground surface (bgs). The sandstone produced approximately 16 gpm to the open test hole. No Significant water zones were encountered in the remaining section of the Minnulesa formation. Cavernous and highly fractures zones were encountered in the limestones of the Madison formation from 365 to 720 feet, but the zones were dry and did not produce water.

Below the Minnulesa and Madison formations, confined ground water was encountered at 1010 and 1110 feet bgs in the upper Deadwood formation. The static water level produced by the two zones in the open test hole was approximately 500 feet. The density-porosity logs indicated that the water zone at 1,010 to 1,030 feet bgs had estimated porosities between 10 and 13 percent. The same logs indicated that the water bearing zone at 1,100 to 1,110 feet bgs had estimated porosities between 7 and 13 percent. Airlifting the open testhole from 1,296 feet indicated that the two zones produced approximately 30 gpm.

The principal aquifer was encountered in the test hole in the lower Deadwood formation in a fine grained quartz sandstone. Significant ground water was encountered at 1,365 feet bgs. The density-porosity log indicates that the porosity at 1,365 feet was approximately 17 percent.

When the principal aquifer was encountered at 1,365 bgs, water was observed flowing at the surface the following day. Before drilling was resumed at 1,365

DRAFT

feet (several days after penetration), the static water level had dropped to approximately 500 feet. The drop in water levels may have been ~~attributed to~~ the result of the high water head pressures produced from the aquifer at 1,365 feet forcing water back into the shallower water zones in the upper Deadwood at 1,010 and 1,100 feet bgs. The shallower water zones in the upper Deadwood formation were sealed off with steel casing from the principal aquifer zone at 1,365 feet bgs. After the shallower water zones were sealed off, the completed well was observed flowing at the surface at approximately 15 gpm. The USGS measured the shut in pressure at the well head to be 78 pounds per square inch (psi). This would prodoce a static water level 177 feet above the ground surface.

The pumping test conducted by EnecoTech in the completed well revealed that the transmissivity of the principal aquifer was 180 gallons per day per foot (gpd/ft). No observation wells were present at the site and hence the transmissivity value could not be confirmed. A literature search did not reveal any published data on the aquifer characteristics in the Deadwood formation in the Black Hills.

Water quality samples were taken during the completion of the pumping test. The water samples taken by EnecoTech were submitted to Twin City Laboratories in Rapid City, South Dakota for determination of nutrients, mineral, dissolved metals and radioactive content. The analytical results are presented in Appendix C. Wendell Bradford with the USGS in Rapid City, also collected a suite of water samples with the approval of Brohm Mining.

6.0 PUMPING TEST

Several testing alternatives were considered in evaluating the aquifer characteristics (transmissivity and storage coefficient) and the maximum sustained yield of the aquifer. The static water level produced by the flowing artesian well was estimated to be 177 feet above ground surface. C.E. Jacob and S.W. Lohman (1952) presented a method to evaluate a flowing artesian aquifer without pumping. Briefly the procedure allows the well to discharge at varing natural flow rates at a constant drawdown. The transmissivity and storage coefficient can then be determined graphically. However, in order to estimate the sustained yield in the aquifer a constant discharge test was conducted to stress the aquifer. In the pumping test the discharge rate was held constant allowing the drawdown to vary. A 55.25 hour constant discharge pumping test was conducted in the test well August 25 through August 27, 1989. The pumping test data are presented in Appendix D.

A 150-horsepower, 25 stage Crown submersible pump was used for the pumping test. The pump intake was set at 1,167.5 feet bgs. A 4-inch diameter riser pipe was attached to the pump and extended to the surface. The discharge line was routed through a Badger in-line totalizing flow meter from which flow rates were regularly calculated. The pump was powered by a skid mounted, 234 kilowatt Caterpillar diesel generator. The pumping rate was maintained at 100 GPM.

During pumping, the water levels were monitored by a 1,300 foot Solinst electronic water level probe. The water level probe was moved up and down inside of a 1-1/2 inch diameter PVC pipe that was attached to the stand-pipe and extended to the pump intake. Water level measurements were taken at the top of the PVC pipe 2.75 feet above the ground surface. Water level measurements were taken as recommended by Krusemaur and DeRidder (1979). Water level measurement time increments were taken at one minute intervals for the first 15 minutes of the pumping test then at five minute intervals until 60 minutes. Measurements were

then taken at 30 minute intervals from 60 to 300 minutes into the test. After 300 minutes, measurements were taken every 60 minutes.

The electronic water level probe became stuck at 1,121 feet at 38.75 hours into the pumping test and could not be freed. The pumping test continued until a new measurement plan could be implemented. The water level reached the pump intake at 55.25 hours into the pumping test. Pumping was stopped immediately so that the pump would not be destroyed. It was assumed that when the pump began to cavitate, that the water level was at approximately 1,155 feet.

The water level recovery data were not recorded due to the stuck water level probe. However, it was observed 2.5 hours later that the well was again flowing at the surface.

The continuous pumping test data were analyzed using the modified Theis nonequilibrium equation (Cooper and Jacob, 1946). The equation was only valid for the time versus drawdown graph after the casing storage effect was negligable. The critical time after which the casing storage no longer contributed to the yield of the well was found to be 255 minutes into the pumping test (Driscoll, 1986, pp. 233). This was also confirmed by the time versus drawdown graph. The transmissivity was calculated from the pumping rate and the slope of the time versus drawdown plot over one log cycle (Appendix E). For practical purposes the drawdowns were measured from the top of the casing not the anticipated static water level above the ground surface. The slope of the change in drawdown on the graph would be uneffected by the scale used. The transmissivity was calculated using the following equation:

$$T = \frac{264\ Q}{\Delta s}$$

where,

T = Transmissivity, gallons per day per foot (gpd/ft)

Q = pumping rate, gallons per minute (gpm)

DRAFT

Δs = Change in drawdown over 1-log cycle of time.

The transmissivity was calculated to be 180 gpd/ft.

Based upon the transmissivity and the saturated thickness of 62 feet, the hydraulic conductivity of the aquifer was calculated to be 3 gallons per day per square feet (gpd/ft^2). The calculated value was representative of fine grained sandstones (Freeze and Cherry, 1979).

The storage coefficient calculated from the drawdown data from the pumped wells are generally not reliable (Driscol, 1986, pp. 222). The storage coefficient was calculated by the method of sussessive approximations as given by Walton (1987) and was based on drawdown data at the end of the test and the nonequalilibrium equation. Several assumed storage coefficient values were used to calculate theoretical drawdowns which were compared to the observed drawdown values. The assumed storage coefficient value that yielded a calculated drawdown equal to the observed value was used. The storage coefficient was estimated to range from 10^{-5} to 10^{-6}. The calculated storage coefficient was representative of confined aquifers (Lohman, 1979).

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7.0 PUMPING RECOMMENDATIONS

The pump test revealed that the well could not sustain a 100 GPM yield for more than 55 hours. The sustained yield for this aquifer was assessed using an analytical model using the Theis equation. The model indicates that a pumping rate of 85 gpm would draw the water level down to approximately 1,250 feet in one year. It was estimated that a 75 gpm pumping rate would draw the water level down to approximately 1,100 feet in one year.

8.0 REFERENCES

Cooper, H.H. Jr. and C.E. Jacob, 1946: A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History, Transactions, American Geophysical Union, Vol. 27, No. 4.

Driscoll, F.G., 1986: Groundwater and Wells, Johnson Division, St. Paul, Minnesota, p. 205-267.

EnecoTech, Inc., 1988: Water Resource Study, Brohm Mining Gilt Edge Sulfide Gold Project Phase I, Identification of Potential Water Supply sites, EnecoTech file: 189-004, July 28, 1988.

Freeze, R.A. and J.A. Cherry, 1979: Groundwater, Prentic-Hall, Inc., Englewood Cliffs, N.J. p.29.

Jacob, C.E. and S.W. Lohnam, 1952: Nonsteady Flow to a Well of Constant Drawdown in a Extensive Aquifer, Transactions, American Geophysical Union, v. 4, pp. 559-569.

Lohnam, S.W., 1979: Ground-Water Hydraulics, Geological Survey Professional Paper 708, 70pp.

Walton, W.C. 1986: Ground Water Pumping Test, Design and Analysis, Lewis Publishers and NWWA, Chelsea Michigan, 201pp.

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APPENDIX D

PUMPING TEST, TIME VERSUS DRAWDOWN DATA

DRAFT

BROHM MINING CORP.- PUMPING TEST DATA FROM TEST WATER WELL WW-1

September 23 from 9:15 a.m. through September 25, 1989 at 4:30 p.m.

Pumping rate= 100 GPM
Measurements taken 2.75 feet above ground surface.

Pump TIME (MINUTES)	Drawdown s (FEET)	TIME (MINUTES)	s (FEET)	TIME (MINUTES)	s (FEET)	TIME (MINUTES)	s (FEET)
1	32.37	145	962.35	275	1001.80	585	1046.35
2	54.67	147	964.14	280	1003.27	590	1048.80
3	71.70	149	965.52	285	1004.53	600	1048.80
4	85.77	151	961.92	290	1004.69	610	1050.75
5	98.40	153	959.94	295	1004.33	620	1050.90
6	110.08	155	960.93	300	1004.20	630	1051.50
7	120.90	157	960.53	305	1004.20	640	1051.75
8	132.77	159	959.34	310	1003.45	645	1050.60
9	144.90	161	965.32	315	1001.92	660	1050.95
10	157.05	163	973.07	320	999.73	675	1048.50
13	206.46	165	979.51	325	1007.30	690	1056.10
14	224.69	167	989.13	330	1008.72	705	1066.65
15	240.26	169	1004.36	335	1003.90	720	1072.50
16	251.50	171	1019.68	340	1005.06	735	1072.80
21	298.62	173	1016.26	345	1004.53	750	1069.45
26	348.95	175	1012.43	350	1005.27	765	1072.05
31	392.89	177	1009.78	355	991.16	780	1073.80
36	498.20	179	1007.66	360	993.95	795	1074.25
41	569.40	181	1006.20	370	1001.62	810	1072.50
46	620.25	183	1004.90	375	1001.26	825	1071.00
51	680.45	185	1003.80	390	1005.25	840	1072.75
56	720.64	187	1003.05	405	1004.73	855	1071.65
61	750.96	189	1002.97	420	1014.87	870	1071.45
71	789.83	191	1001.45	435	1014.75	885	1071.50
81	823.50	193	1000.07	450	1017.13	900	1073.25
82	822.42	195	998.73	460	1019.00	915	1075.05
83	824.52	197	997.45	465	1018.55	930	1074.55
84	827.05	179	995.20	470	1018.13	945	1072.20
85	828.95	201	992.07	475	1017.92	960	1072.65
95	860.65	203	986.98	480	1017.68	975	1076.20
105	880.76	205	983.07	485	1017.75	990	1078.40
115	912.10	210	984.03	490	1015.15	1005	1082.15
125	953.27	215	985.18	495	1020.39	1020	1084.35
130	963.31	220	985.44	500	1029.32	1035	1086.05
131	959.65	225	984.50	505	1032.00	1050	1087.15
132	958.40	230	990.05	510	1034.58	1065	1088.25
133	958.32	235	999.20	515	1036.72	1080	1088.80
134	958.30	237	1001.73	520	1037.80	1095	1089.25
135	958.05	239	1003.03	525	1039.00	1110	1089.75
137	957.66	241	1003.01	530	1037.90	1125	1089.95
138	957.42	243	1002.75	535	1036.82	1140	1087.90
139	956.70	245	1002.26	540	1036.23	1155	1087.65
140	957.45	250	1001.97	550	1035.90	1170	1086.40
141	955.92	255	1001.42	555	1036.70	1185	1087.35
142	957.20	260	1000.36	565	1038.35	1200	1087.54
143	959.20	265	1000.03	571	1040.25	1215	1087.10
144	960.95	270	999.33	580	1043.85	1230	1086.50

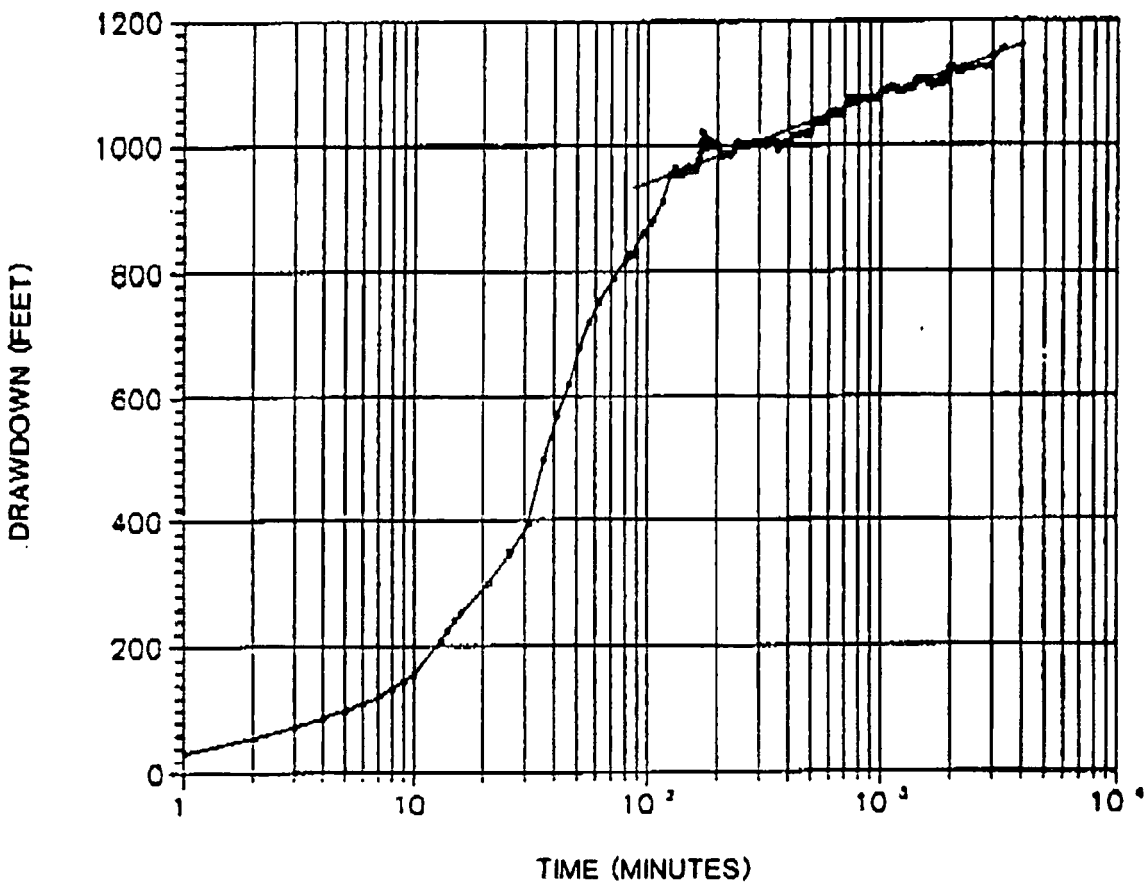
TIME (MINUTES)	S (FEET)	TIME (MINUTES)	S (FEET)	
1245	1087.35	2030	1121.07	
1260	1087.52	2035	1121.12	
1275	1086.10	2040	1121.10	
1290	1088.03	2045	1121.07	
1305	1088.55	2050	1121.10	
1320	1088.38	2055	1121.12	
1335	1088.23	2060	1121.13	
1350	1088.10	2065	1121.30	
1365	1088.29	2070	1121.30	
1380	1094.61	2075	1120.72	
1395	1099.35	2080	1120.27	
1410	1101.80	2085	1120.05	
1425	1101.95	2090	1120.10	
1440	1103.00	2095	1119.95	
1455	1102.30	2100	1119.86	
1470	1102.15	2115	1119.96	
1500	1101.98	2145	1119.93	
1515	1103.29	2175	1118.12	
1545	1102.70	2205	1119.63	
1560	1102.30	2235	1117.30	
1575	1101.00	2265	1124.55	
1605	1097.40	2295	1122.75	
1635	1093.40	2415	1122.21	
1665	1091.40	2438	1122.25	
1695	1096.85	2825	1124.56	
1725	1098.63			
1755	1099.25	3315	1155.00	Pump begins to cavitate,
1785	1099.20			stop pump- estimate that water
1800	1102.80			level at approximately 1155 feet
1815	1106.27			
1830	1105.45			
1845	1102.40			
1860	1102.00			
1875	1099.77			
1890	1101.32			
1905	1103.15			
1907	1103.80			
1920	1110.60			
1935	1117.87			
1940	1120.17			
1945	1121.53			
1950	1122.15			
1955	1121.76			
1960	1121.20			
1965	1120.85			
1970	1120.55			
2020	1121.05			

APPENDIX E

PUMPING TEST, TIME VERSUS DRAWDOWN GRAPH

DRAFT

PUMPING TEST DRAWDOWN



Drawdown (Δs)=147' (measurements taken 2.75 feet above ground surface)

Discharge (Q)=100 gpm (gallons per minute)

Transmissivity*: $T = \frac{264 \times Q}{\Delta s}$

T=180 gpd/ft (gallons per day per feet of drawdown)

* *Modified nonequilibrium equation, Jacob Strait - Line Analysis, (Cooper & Jacob, 1946)*

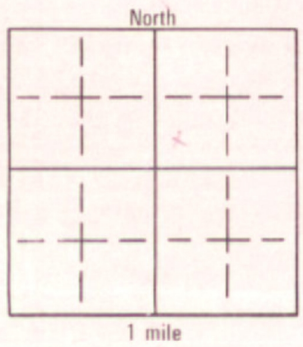
EnecoTech Denver Colorado	BROHM MINING CO.	TIME VS DRAWDOWN GRAPH
Project	LOST GULCH TEST WATER WELL WW-1	
File No.: 189-010	Date: SEPTEMBER, 1989	

SOUTH DAKOTA WATER WELL COMPLETION REPORT 10-85

Location SW ¼ NE ¼ Sec 27 Twp 4E Rg 5N

County Lawrence

Please mark well location with an "X"



Well Completion Date 7/28/89

PROPOSED USE:
☐ Domestic ☐ Municipal ☐ Test Holes
☐ Irrigation ☒ Industrial ☐ Stock

Method of Drilling:
AIR - ROTARY

CASING DATA:
☒ Steel ☐ Plastic ☐ Other
If other describe

PIPEWEIGHT	DIAMETER	FROM	TO	HOLE DIAMETER
48 LB/FT	12 3/4 IN	0 FT	416 FT	14 3/4 IN
24 LB/FT	8 5/8 IN	384 FT	1290 FT	11 IN
___ LB/FT	___ IN	___ FT	___ FT	___ IN
___ LB/FT	___ IN	___ FT	___ FT	___ IN

GROUT:
Was the well grouted? ☒ YES ☐ NO
To what depth? 1290 FEET
What is grouting material? CEMENT
If cement, number of sacks? 434
Describe grouting procedure 2 CASING STRINGS PRESSURE GROUTED SEPERATLY
What was grout weight? 15 LB/GAL

SCREEN: ☐ Perforated pipe ☐ Manufactured
Diameter ___ IN Length ___ FEET
Material ___
Slot Size ___ Set From ___ Feet To ___ Feet
Slot Size ___ Set From ___ Feet To ___ Feet
Slot Size ___ Set From ___ Feet To ___ Feet
Other information ___

Was a packer or seal used? ☐ YES ☒ NO
If so, what naterial? ___
Describe packer(s) and location? ___

Was well disinfected upon completion? ☒ YES ☐ NO
Explain CIRCULATED CHLORINE SOLUTION
Bacteriological analysis ☐ YES ☐ NO
Laboratory sent to DID NOT SET PERMANENT PUMP

Well Owner:
Name Brohn Mining Corporation
Address P.O. Box 485 Deadwood, SD 57732

Well Log:

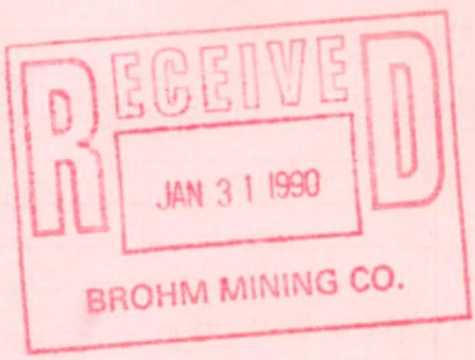
Formation	Depth From	Depth To
ALLUVIUM	0	18
MINNELUSA	18	247
MADISON	247	720
ENGLEWOOD	720	760
WHITEWOOD	760	810
WINNIPEG	810	912
DEADWOOD	912	1412

STATIC WATER LEVEL -0- Feet
If flowing closed in pressure ___ PSI
GPM flow ___ through ___ inch pipe
Controlled by ☒ Valve ☐ Reducers ☐ Other
If other; specify ___
Can well be completely shut in? YES CASING ATTACHED DIAGRAM

WELL TEST DATA:
☒ Pumped
☐ Bailed Describe:
☐ Other
Pumping Level Below Land Surface
-0- ft. After ___ Hrs. pumped 15 GPM
1140 ft. After 48 Hrs. pumped 100 GPM
___ ft. After ___ Hrs. pumped ___ GPM

REMARKS:

This well was drilled under license # 331
And this report is true and accurate.
Drilling firm TAYLOR DRILLING COMPANY
Signature of License Representative:
Ron Taylor
Signature of Well Owner:
Date 9-8-89


RECEIVED
JAN 31 1990
BROHM MINING CO.

ENECOTECH

FACSIMILE
(303) 293-2735

DATE: 7-11-89 TIME: 1015 (a.m.) or _____ p.m.

TO: Jim Barron
BROHM MINING CORP
P.O. Box 485
Deadwood, SD. 57732
Phone: (605) 578-1709

PRIORITY: ✓ Normal
_____ Urgent

FROM: BRIAN TILTON

Project: 189-010 WATER RESOURCES

Please call (303) 293-2703 if you do not receive the number of pages listed below or if you have a problem.

Number of Pages (Including Cover Sheet): 4

COMMENTS: Original letter will be mailed to you today Concerning well completion cost estimates.

EnecoTech

July 11, 1989

189-010

Brohm Mining Corporation
ATTN: Mr. Jim Barron
P.O. Box 485
Deadwood, South Dakota 57732

Dear Mr. Barron:

Enclosed please find the revised cost estimates for the completion of WW-1 in Lost Gulch. The estimates include Taylor Drilling's costs for reaming and casing the existing borehole and EnecoTech's involvement with the pump test (Task 5) and report preparation (Task 6). Also, included are the cost estimates for EnecoTech and Taylor Drilling's work June 9 through June 30, 1989.

Should you have any questions regarding these estimates, please contact us at your convenience.

Sincerely,

Brian Tilton
Geological Engineer

Barry L. Stewart
Principal

Enclosure

BT/KLW/ch

Well Completion Cost Estimates

1. 0-420 feet

Ream 8-3/4 to 14-3/4 inch borehole ($30/ft)	$12,600.00
Cement casing ($150/hr + $8 sack cement)	1,000.00
12-inch I.D. casing ($28.50/ft installed)	11,970.00
	$25,570.00

2. 420-1,350 feet

Ream 8-3/4 inch (420-720') and 6-1/4 inch (720-1,260') and 5-7/8 inch (1,260-1,350') to 11 inch borehole ($15/ft)	$13,950.00
Cement ($4/ft)	3,720.00
8-inch I.D. casing ($18/ft installed)	16,740.00
	$34,410.00

3. 1,350-1,412 feet

Reem 5-7/8 to 7-7/8 inch borehole (Rig Time $150.00/hr, estimated 6 hours)	$ 900.00

TOTAL **$60,880.00**

* Estimates from phone conversation with Randy Taylor on July 6, 1989.

EnecoTech

TASK 5: Conduct Aquifer Test

Taylor Drilling Expense Estimates

Supply Test Pump and Installation of Equipment		$11,000.00
Run pump	128.0 hrs @ $75.00/hr	9,600.00
		$20,600.00

EnecoTech Labor

Project Hydrogeologist (Pump Test Set Up)	4.0 hrs @ $45.00/hr	$ 180.00
Staff Hydrogeologists (2) (8-hour step pump test and 120-hr continuous pump test)	135.0 hrs @ $35.00/hr	4,725.00
Staff Hydrogeologists (2) (Recovery Test)	50.0 hrs @ $35.00/hr	1,750.00
		$ 6,655.00

Expenses

Airfare (2)		$ 500.00
2 Vehicles	8.0 days @ $50.00 each/day	800.00
Per Diem	8.0 days @ $70.00 each/day	1,120.00
Sample Bottles		50.00
Sample Analysis		360.00
Test Equipment (includes pH/conductivity meter water level probe and miscellaneous equipment)	$70.00/day	560.00
		$ 3,390.00

TASK 5 TOTAL $30,645.00

EnecoTech

TASK 6: Report Preparation and Submittal

Labor

Senior Hydrogeologist	10.0 hrs @ $55.00/hr	$ 550.00
Project Hydrogeologist	60.0 hrs @ $45.00/hr	2,700.00
Staff Hydrogeologist	15.0 hrs @ $35.00/hr	525.00
Secretarial	12.0 hrs @ $25.00/hr	300.00
Drafting	16.0 hrs @ $25.00/hr	400.00
	Labor Total	$ 4,475.00

Expense

Photocopies	250.0 copies @ $0.10/copy	$ 25.00
Drafting/Graphics		100.00
	Expense Total	$ 125.00

TASK 6 TOTAL $ 4,600.00

Lost Gulch Target Total

1. Cost Estimates from Initial Boring June 9 through 30, 1989	
Taylor Drilling	$30,000.00
EnccoTech Cost and Expenses	10,000.00
2. Pump Test	30,085.00
3. Completion of Existing Well	60,880.00
4. Report Preparation	4,600.00

TOTAL **$135,565.00**

D\BROHM\188010\LOSTGUL.CE

EnecoTech

ENECOTECH

July 7, 1989

Brohm Mining Corporation
ATTN: Mr. Jim Barron
P.O. Box 485
Deadwood, South Dakota 57732

189-010

SUBJECT: Completion of Water Well 1 Located at SW1/4, NE1/4, Section 27, T5N, R4E, Lawrence County, South Dakota

Dear Mr. Barron:

The following presents a brief description of the anticipated WW-1 well completion:

- Ream existing 8-3/4 inch borehole to 14-3/4 inches from the surface to 420 feet. Twelve inch I.D. casing will then be set and cemented from the surface to 420 feet.
- Ream existing 8-3/4 inch (420 to 720 feet) and 6-1/4 inch borehole (720 to 1,350 feet) to 11 inches. Eight inch I.D. casing will then be set and cemented in from 420 to 1,350 feet.
- The aquifer zone of interest will then be reamed from 5-7/8 to 7-7/8 inches from 1,350 to 1,412 feet and will remain uncased. A decision will be made at this point as to whether the borehole will be extended from 1,412 to 1,500 feet.
- After the well has been completed, the water from the aquifer will be airlifted to estimate the flowrate.
- A test pump will then be set in the well to test the aquifer characteristics and to estimate the optimum pumping rate. The pump test will be conducted continuously for 120 hours. At the conclusion of pumping, recovery will be measured for 48 hours.

Should you have any questions regarding this plan, please contact us at your convenience.

Sincerely,

Brian Tilton
Geological Engineer

Kenneth L. Walter
Project Hydrogeologist

D\BROHM\189010\GEE.LTR

Trinity Place, Suite 700 • 1801 Broadway • Denver, Colorado 80202 • (303) 293-2703

BY B. TILTON DATE 7-7-89 ENECOTECH INC. SHEET 1 OF 1

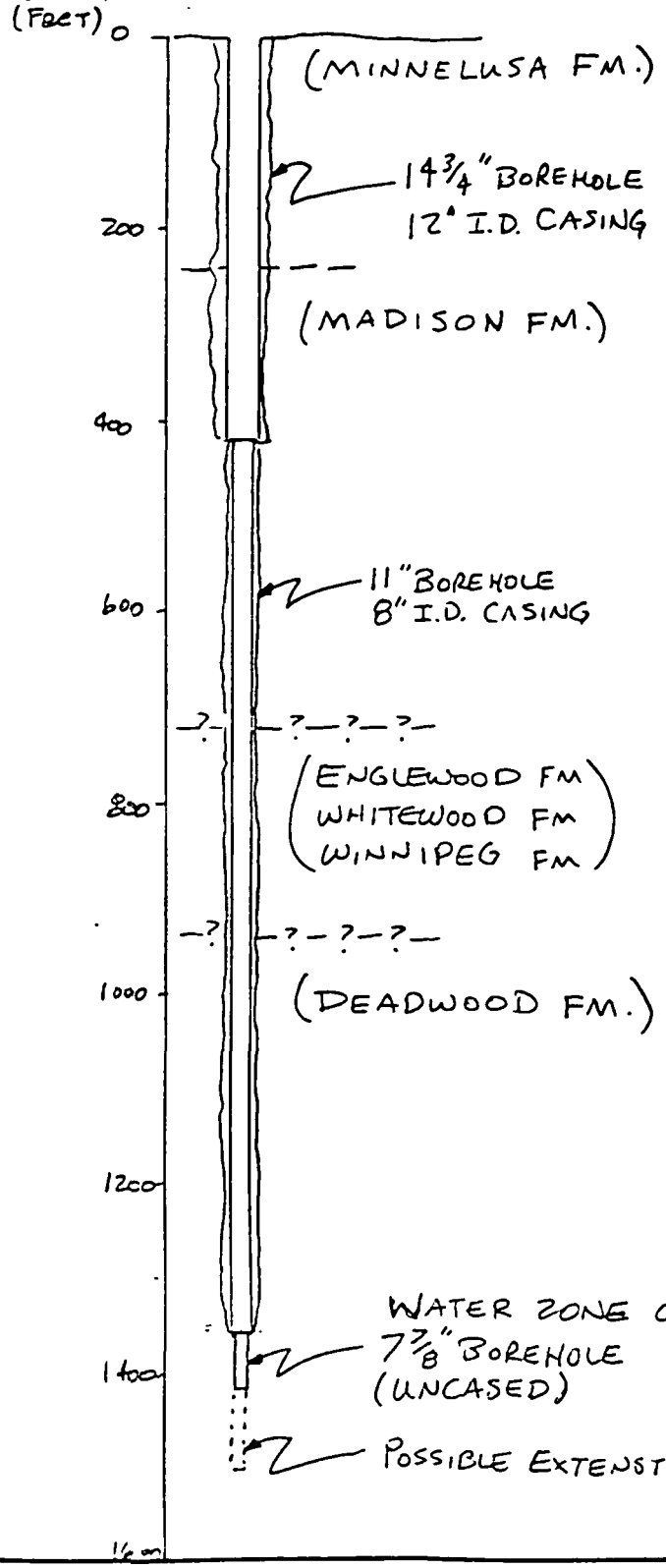
CHKD. BY _____ DATE _____

CLIENT BROHM MINING CORP. — JIM BARRON

PROJECT WATER RESOURCE INVESTIGATION

SUBJECT WATER WELL #1, LOST GULCH

LOCATION: SW¼ NE¼ SECTION 27, T5N, R4E
LAWRENCE COUNTY, SOUTH DAKOTA
SURFACE ELEVATION ~ 4470 FEET



WELL CONSTRUCTION

0-420' 14¾" BOREHOLE
12" I.D. CASING

420-1350' 11" BOREHOLE
8" I.D. CASING

1350-1412' 7⅞" BOREHOLE
UNCASED

* ALL CASING WILL BE CEMENTED IN TO CONFORM WITH SOUTH DAKOTA REGULATIONS

BY B. TILTON DATE 7-7-89 ENECOTECH INC. SHEET 1 OF 3

CHK'D. BY _____ DATE _____

CLIENT BROHM MINING CORP. - Jim Barron

PROJECT WATER RESOURCE INVESTIGATION

SUBJECT COST ESTIMATES TO COMPLETE WW-1

A.) WELL COMPLETION

1.) 0-420 Feet

Ream 8 3/4 to 14 3/4 inch borehole ($30/ft)	$12,600.00
Cement casing ($150/hr + $8 sack cement)	~1,000.00
12 inch I.D. Casing ($28.50/ft installed)	11,970.00
	$25,570.00

2.) 420-1350 Feet

Ream 8 3/4" (420-720') and 6 1/4" (720-1260') and 5 7/8" (1260-1350') to 11 inch borehole ($15/ft)	13,950.00
Cement ($4/ft)	3,720.00
8 inch I.D. Casing ($18/ft installed)	16,740.00
	$34,410.00

3.) 1350-1412 Feet

Ream 5 7/8 to 7 7/8 inch borehole ($150/hr. est. 6 hrs)	$900.00
* TOTAL	$60,880.00

(* Randy Taylors estimate from Phone Conversation July 6, 1989)

TASK 5

B.) Pump Test

1.) Taylor Drilling

Supply test pump and install	2	$11,000.00
Run Pump	($75/hr x 128 hrs)	$9,600.00
		$20,600.00

2.) EnecoTech Labor

Project Hydrogeologist (Pump Test Setup) 4.0 hrs @ $45/hr.	$180.00
2 Staff Hydrogeologists (Step & Continuous Pump Test) 135.0 hrs @ $35/hr.	$4,725.00
2 Staff Hydrogeologists (Recovery Test) 50.0 hrs @ $35/hr.	$1,750.00
	$6,655.00

3.) Expenses

Airfare (2)		$500.00
2 Vehicles	8 days @ $50 each/day	$800.00
Per Diem	8 days @ $70 each/day	$1,120.00
Sample Bottles		$50.00
Sample Analysis		$360.00
		$2,830.00

TASK 5 TOTAL $30,085.00

BY _____ DATE _____ ENECOTECH INC. SHEET 3 OF 3

CHKD. BY _____ DATE _____

CLIENT TASK 6

PROJECT _____

SUBJECT _____

C.) REPORT PREPARATION AND SUBMITTAL

LABOR

SENIOR Hydrogeologist	10.0 hrs @ $55/hr	$550.00
Project Hydrogeologist	60.0 hrs. @ $45/hr	2700.00
STAFF Hydrogeologist	15.0 hrs @ $35/hr	525.00
SECRETARIAL	12.0 hrs @ $25/hr.	300.00
DRAFTING	16.0 hrs @ $25/hr.	400.00
		$4,475.00

EXPENSES

Photocopies	250 @ 0.10/copy	$25.00
Drafting/Graphics		100.00
EXPENSE TOTAL		$125.00

TASK 6 TOTAL $4,600.00

1) INITIAL BORING TAYLOR	~ $30,000.00
ENECOTECH	~ 10,000.00
2) PUMP TEST	30,085.00
3) COMPLETION OF WELL	60,880.00
4) REPORT	4,600.00
TOTAL	$135,565.00

ENECOTECH

July 7, 1989

Brohm Mining Corporation
ATTN: Mr. Jim Barron
P.O. Box 485
Deadwood, South Dakota 57732

189-010

SUBJECT: Completion of Water Well 1 Located at SW1/4, NE1/4, Section 27, T5N, R4E, Lawrence County, South Dakota

Dear Mr. Barron:

The following presents a brief description of the anticipated WW-1 well completion:

- Ream existing 8-3/4 inch borehole to 14-3/4 inches from the surface to 420 feet. Twelve inch I.D. casing will then be set and cemented from the surface to 420 feet.
- Ream existing 8-3/4 inch (420 to 720 feet) and 6-1/4 inch borehole (720 to 1,350 feet) to 11 inches. Eight inch I.D. casing will then be set and cemented in from 420 to 1,350 feet.
- The aquifer zone of interest will then be reamed from 5-7/8 to 7-7/8 inches from 1,350 to 1,412 feet and will remain uncased. A decision will be made at this point as to whether the borehole will be extended from 1,412 to 1,500 feet.
- After the well has been completed, the water from the aquifer will be airlifted to estimate the flowrate.
- A test pump will then be set in the well to test the aquifer characteristics and to estimate the optimum pumping rate. The pump test will be conducted continuously for 120 hours. At the conclusion of pumping, recovery will be measured for 48 hours.

Should you have any questions regarding this plan, please contact us at your convenience.

Sincerely,

Brian Tilton
Geological Engineer

Kenneth L. Walter
Project Hydrogeologist

D\BROHM\189010\GEE.LTR

BY B. TILTON DATE 7-7-89 ENECOTECH INC. SHEET 1 OF 1

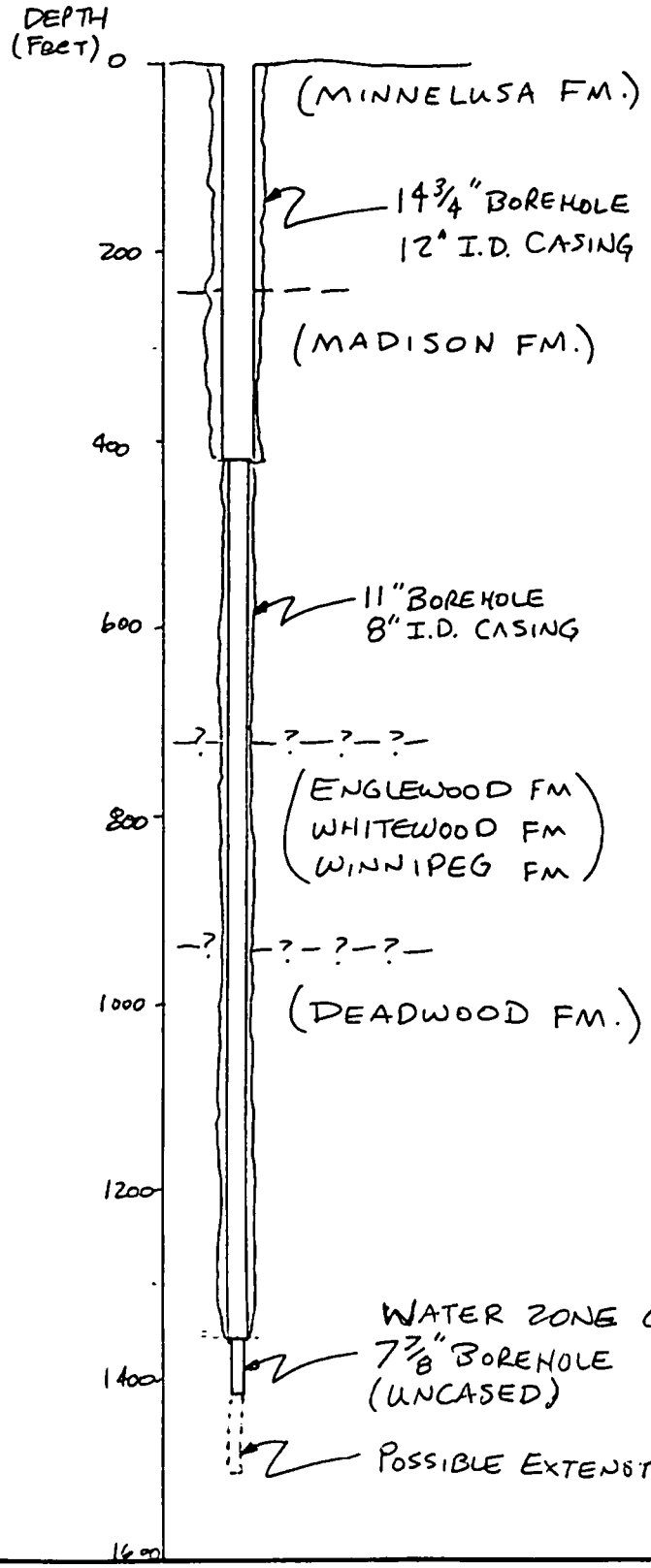
CHKD. BY _____ DATE _____

CLIENT BROHM MINING CORP. — JIM BARRON

PROJECT WATER RESOURCE INVESTIGATION

SUBJECT WATER WELL #1, LOST GULCH

LOCATION: SW¼ NE¼ SECTION 27, T5N, R4E
LAWRENCE COUNTY, SOUTH DAKOTA
SURFACE ELEVATION ~ 4470 FEET



WELL CONSTRUCTION

0-420' 14 5/4" BOREHOLE
12" I.D. CASING

420-1350' 11" BOREHOLE
8" I.D. CASING

1350-1412' 7 7/8" BOREHOLE
UNCASED

* ALL CASING WILL BE CEMENTED IN TO CONFORM WITH SOUTH DAKOTA REGULATIONS

BY B. TILTON DATE 7-7-89 ENECOTECH INC. SHEET 1 OF 3

CHKD. BY _____ DATE _____

CLIENT BROHM MINING CORP. - Jim Barron

PROJECT WATER RESOURCE INVESTIGATION

SUBJECT COST ESTIMATES TO COMPLETE WW-1

A.) WELL COMPLETION

1.) 0-420 Feet

Ream 8 3/4 to 14 3/4 inch borehole ($30/ft)	$12,600.00
Cement casing ($150/hr + $8 sack cement)	~1,000.00
12 inch I.D. casing ($28.50/ft installed)	11,970.00
	$25,570.00

2.) 420-1350 Feet

Ream 8 3/4" (420-720') and 6 1/4" (720-1260') and 5 7/8" (1260-1350') to 11 inch borehole ($15/ft)

	13,950.00
Cement ($4/ft)	3,720.00
8 inch I.D. Casing ($18/ft installed)	16,740.00
	$34,410.00

3.) 1350-1412 Feet

Ream 5 7/8 to 7 7/8 inch borehole ($150/hr. est. 6 hrs)

	$900.00
* TOTAL	$60,880.00

(* Randy Taylors estimate from Phone Conversation July 6, 1989)

BY _____ DATE _____ ENECOTECH INC. SHEET 2 OF 3

CHKD. BY _____ DATE _____

CLIENT TASK 5

PROJECT _____

SUBJECT _____

B.) Pump Test

1.) Taylor Drilling

Supply test pump and install		$11,000.00
Run Pump	($75/hr x 128 hrs)	$9,600.00
		$20,600.00

2.) EnecoTech Labor

Project Hydrogeologist (Pump Test Setup)		
4.0 hrs @ $45/hr.		$180.00
2 Staff Hydrogeologists (Step & Continuous Pump Test)		
135.0 hrs @ $35/hr.		$4,725.00
2 Staff Hydrogeologists (Recovery Test)		
50.0 hrs @ $35/hr.		$1,750.00
		$6,655.00

3.) Expenses

Airfare (2)		$500.00
2 Vehicles	8 days @ $50 each/day	$800.00
Per Diem	8 days @ 70 each/day	$1,120.00
Sample Bottles		$50.00
Sample Analysis		$360.00
		$2,830.00

Task 5 Total $30,085.00

BY _____ DATE _____ ENECOTECH INC. SHEET 3 OF 3

CHKD. BY _____ DATE _____

CLIENT TASK 6

PROJECT _____

SUBJECT _____

C.) REPORT PREPARATION AND SUBMITTAL

LABOR

SENIOR Hydrogeologist	10.0 hrs @ $55/hr	$550.00
Project Hydrogeologist	60.0 hrs @ $45/hr	2700.00
STAFF Hydrogeologist	15.0 hrs @ $35/hr	525.00
SECRETARIAL	120 hrs @ $25/hr.	300.00
DRAFTING	16.0 hrs @ $25/hr.	400.00
		$4,475.00

EXPENSES

Photocopies	250 @ 0.10/copy	$25.00
Drafting/Graphics		100.00
EXPENSE TOTAL		$125.00

TASK 6 TOTAL $4,600.00

1) INITIAL BORING TAYLOR	~ $30,000.00
ENECOTECH	~ 10,000.00
2) PUMP TEST	30,085.00
3) COMPLETION OF WELL	60,880.00
4) REPORT	4,600.00
TOTAL	$135,565.00

sent UPS overnite

BROHM MINING CORP.

March 28, 1989

Mr. Tim Thomas
Sargent Irrigation Company
South Highway 21
Broken Bow, Nebraska 68822

Dear Mr. Thomas:

Brohm Mining Corporation (Brohm) invites your bid proposal for the drilling, testing, development and completion of a water well in the Deadwood, South Dakota, area.

Our plan is to drill one pilot boring of sufficient diameter and depth to determine potential yield. It may be possible, according to a hydrologist's report, to develop a point source yielding up to 2000 gpm from the Pahasapa (Madison) Limestone and Deadwood Formation.

We anticipate drilling this test well to a depth of approximately 1300 feet or less. We wish to begin this work as soon as possible.

With your bid, please provide proposed costs for test pumping and E-logging of the test well with SP, resistivity and gamma-gamma density. Also, please submit your South Dakota water well drillers license number and the earliest date which you could begin this work. Also, please stipulate the equipment you anticipate providing to complete this work and mobilization/ demobilization rates for that equipment.

If you have any questions regarding this proposal, please call me at the phone number shown. If you cannot furnish us with a proposal at this time, please inform us of this as well.

Sincerely,
Brohm Mining Corporation

J. N. Barron

James N. Barron
Sr. Exploration Geologist

JNB/dvl

South Dakota Office: P.O. Box 485, Deadwood, South Dakota 57732
Telephone: (605) 578-2107 Telecopier: (605) 578-1709

Sent next DAY Air thru Post Office

BROHM MINING CORP.

March 28, 1989

Mr. Bruce G. Jones, Jr.
B & B Drilling Company
P.O. Box 2666
Grand Junction, CO 81502

Dear Mr. Jones:

Brohm Mining Corporation (Brohm) invites your bid proposal for the drilling, testing, development and completion of a water well in the Deadwood, South Dakota, area.

Our plan is to drill one pilot boring of sufficient diameter and depth to determine potential yield. It may be possible, according to a hydrologist's report, to develop a point source yielding up to 2000 gpm from the Pahasapa (Madison) Limestone and Deadwood Formation.

We anticipate drilling this test well to a depth of approximately 1300 feet or less. We wish to begin this work as soon as possible.

With your bid, please provide proposed costs for test pumping and E-logging of the test well with SP, resistivity and gamma-gamma density. Also, please submit your South Dakota water well drillers license number and the earliest date which you could begin this work. Also, please stipulate the equipment you anticipate providing to complete this work and mobilization/ demobilization rates for that equipment.

If you have any questions regarding this proposal, please call me at the phone number shown. If you cannot furnish us with a proposal at this time, please inform us of this as well.

Sincerely,
Brohm Mining Corporation

James N. Barron
Sr. Exploration Geologist

JNB/dvl

South Dakota Office: P.O. Box 485, Deadwood, South Dakota 57732
Telephone: (605) 578-2107 Telecopier: (605) 578-1709
Brohm Mining Corp. is a wholly owned affiliate of Minven Gold Corporation

BROHM MINING CORP.

March 28, 1989

Mr. Randy Taylor
Taylor Drilling Company
2310 Commerce Road
Rapid City, SD 57702

Dear Mr. Taylor:

Brohm Mining Corporation (Brohm) invites your bid proposal for the drilling, testing, development and completion of a water well in the Deadwood, South Dakota, area.

Our plan is to drill one pilot boring of sufficient diameter and depth to determine potential yield. It may be possible, according to a hydrologist's report, to develop a point source yielding up to 2000 gpm from the Pahasapa (Madison) Limestone and Deadwood Formation.

We anticipate drilling this test well to a depth of approximately 1300 feet or less. We wish to begin this work as soon as possible.

With your bid, please provide proposed costs for test pumping and E-logging of the test well with SP, resistivity and gamma-gamma density. Also, please submit your South Dakota water well drillers license number and the earliest date which you could begin this work. Also, please stipulate the equipment you anticipate providing to complete this work and mobilization/ demobilization rates for that equipment.

If you have any questions regarding this proposal, please call me at the phone number shown. If you cannot furnish us with a proposal at this time, please inform us of this as well.

Sincerely,
Brohm Mining Corporation

J.N. Barron

James N. Barron
Sr. Exploration Geologist

JNB/dvl

South Dakota Office: P.O. Box 485, Deadwood, South Dakota 57732
Telephone: (605) 578-2107 Telecopier: (605) 578-1709
Brohm Mining Corp. is a wholly owned affiliate of Minven Gold Corporation

MADISON AQUIFER APPROPRIATIONS (PERMITS) (UNITS = CFS)
IN SOUTH DAKOTA (COMPILED BY J BARRON)

SOURCE: SD-DWNR PRINTOUT OF "MADISON AQUIFER PERMITS, (3/8/89) OBTAINED FROM JAMES GOODMAN, Hydrologist, ENGINEER, DIV. OF WATER RIGHTS

COUNTY	IRRIGATION (# PERMITS)	MUNICIPAL (# PERMITS)	RWS + DOM + SHD (# PERMITS)	IND + COM (# PERMITS)	GEOTHERMAL (# PERMITS)	TOTAL CFS =	gpm	LICENSED CFS (# OF LICENSES)	pH	WATER ALK (m)	QUALITY HARD. ($CaCO_3$)	TDS	AVERAGE WELL DEPTH (N)
BUTTE	26.02 (5)	2.23 (1)	1.34 (3)			29.59 (9)	13,256.32	14.54 (6)	7.25	204	351	322	3,320' (1)
DEWEY		1.02 (1)				1.02 (1)	457.96	0.60 (1)					
FALL RIVER	9.36 (1)	4.59 (4)		2.55 (2)		16.50 (7)	7,392	12.78 (6)	7.11	180	497	1163	3482' (3)
HAAKON	11.12 (2)	2.55 (3)			2.7 (2)	16.37 (7)	7,333.76	2.86 (3)	7.45	120	858	1320	3660' (2)
LAWRENCE	5.16 (5)	7.00 (5)	0.42 (3)	1.47 (4)		14.05 (17)	6,294.40	4.26 (5)	8.04	187	183	210	719' (3)
HUGHES				2.22 (1)		2.22 (1)	994.56	0.0					
MEADE		5.70 (3)	(RWS) 3.50 (3)			9.20 (6)	4,128.60	5.26 (3)	7.53	182	261	295	1,621' (5)
PENNINGTON		4.06 (4)	2.80 (12)	2.00 (1)		8.86 (17)	3,969.28	3.36 (7)	7.31	181	258	357	2,070' (7)
PERKINS		4.45 (1)				4.45 (1)	1,993.60	0.0					
STANLEY	2.00 (1)					200 (1)	896.00	0.0					
ZIEBACH		0.50 (1)				0.50 (1)	224.00	0.19 (1)	7.80	118	1365	2435	4700' (1)
TOTAL (CFS)	53.66	32.10	8.06	8.24	2.7	109.76		43.85					
(gpm)	24,040	14,381	3,611	3,692	1210	46,932.48		(32)					
(# permits)	(14)	(22)	(21)	(8)	(2)	(67)		19,644.8 gpm					

SOUTH Dakota Department of
Water & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, South Dakota 57501

July 24, 1984

Daniel A Fredlund
Sub Rt, Box 307-1
Rapid City SD 57702

Dear Mr. Fredlund:

Enclosed herewith is your Water Permit No. 1308-1 as approved by the Water Management Board authorizing you to construct your water diversion system and the water to beneficial use, not exceeding the limits as specified in said Water Permit No. 1308-1.

Also enclosed is Form 10, Notice of Completion of Works and Application of Water to Beneficial Use, which you are to complete and submit to the Chief Engineer when you have completed the system and/or have put the water to beneficial use. An inspection can then be scheduled so that your Water License may be issued to you, thus completing your acquistion of a Water Right.

Very truly yours,

John Hatch

JOHN HATCH, Chief Engineer
Water Rights Division

JH:ks

enclosure

PLEASE NOTE: Certain changes can be made in your permit within the five year construction period, usually without affecting the priority date provided an application to amend your permit is made within the five year period-i.e. changes in location or number of diversion points (wells) or location of land to be irrigated. Well locations for wells into the same aquifer can be moved up to 660 feet without application.

Applications to amend a permit after the five year construction period will be assigned a new priority date. Applications to change water sources, to add lands or increase original diversion rates, if approved will usually receive the date of the new application as a priority date regardless of the five year construction period.

WATER PERMIT

The Water Management Board hereby approves Water Permit Application No. 1308-1

Daniel A Fredlund (Applicant) Box 307-1, Rapid City (Post Office Address)

South Dakota (State) 57702 (Zip Code) With the following qualifications.

The wells approved under this Permit are located near domestic wells which may obtain water from the same aquifer. The well owner, under this Permit, shall control his withdrawals so there is not a reduction of needed water supplies in adequate domestic wells.

Date of first receipt of application March 22, 1984.

Date of return to applicant for correction, amendments or changes required _____, 19____.

Date of receipt of corrected application _____, 19____. Approved July 11, 1984.

The Water Management Board hereby approves this Water Permit No. 1308-1 authorizing the construction of the water use system and the placing of water to beneficial use as stated in the Application and as qualified in the Water Permit approval, subject, however, to the following limitations and conditions:

1. The date from which applicant may claim right is March 22, 1984.
2. The equivalent of at least one-fifth of the specified work is to be completed on or before January 11, 1987.
3. The whole of said work is to be completed on or before July 11, 1989.
4. The limit of time from proof of beneficial use of water appropriated in accordance herewith is July 11, 1993.
5. The water appropriated shall be used for the purpose of Industrial (mining)
6. The prior right of all persons who, by compliance with the laws of the State of South Dakota, have acquired a right to the use of water must not be unlawfully impaired by this appropriation.
7. The amount of the appropriation herein granted shall not exceed 0.10 cubic feet per second; neither shall it exceed the capacity of the above described water supply system nor shall it exceed the amount of water needed for beneficial uses served and to which water is actually and beneficially applied for industrial purposes on or before July 11, 1993; said water to be used during the following described annual period: year around

WATER MANAGEMENT BOARD

By: John Hoth (Chief Engineer)

Division of Water Rights
Dept. of Water and Natural Resources

_____, 19____

FORM 2: Application for uses other than irrigation (type or print)

Mail to: Water Rights Div.
DWNR, Foss Bldg.
Pierre, SD 57501
(605) 773-3352

No. 1308-1 Hydrologic Unit 10120202
Map No. 1308-1 Basin BF
Newspaper DAILY CALL, Lead SD

Application For Permit To Appropriate Water Within The State Of South Dakota

Check use of water: Industrial ☑ Commercial ☐ Municipal ☐ Other Common Distribution System ☐
Rural Water System ☐ Suburban Housing ☐ Geothermal Heat ☐ Institutional ☐ Recreational ☐
Domestic ☐ (above 18gpm) Other ☐

9:30 AM MAR 198- DIVISION OF WATER RIGHTS Pierre, SD

2 appl for maps

Type of Application: Check one or more of the following

New ☑ Vested Right ☐ Future Use ☐ Change Use ☐
☐ Amend Permit No._____ with old priority date retained
Change diversion point(s) ☐ Add diversion point(s) ☐ Other ☐ _____
☐ Application to: Change diversion point(s) ☐ Add diversion point(s) ☐ on Permit No. _____
☐ Construction to use water reserved by Future Use Permit No._____

1. Name of Applicant Daniel A. Fredlund Phone No. 348-3763
   Post Office Address Sub. Rt. Box 307-1, Rapid City (Street, RR or Box) State SD Zip Code 57702
2. Amount of water claimed (c.f.s) 0.10 cfs
3. Source of water supply (Alluvium & basal conglomerate of Deadwood formation) sufrace and ground water, Lot 8 & Lot 12, Sec 5, T4N, R4E
4. Location of point of diversion (A) 2320'N, 30'W; (B) 1860'N, 150'E; (C) 1450N, 80'W; (D) 1930'N, 530'E; (E) 1750'N; (F) 900'N, 150'W; all from quarter corner Section 5 - Section 8, T4N, R4E, BHM. County Lawrence
5. Counties where water will be used Lawrence
6. Annual period during which water is to be used Year-long, but mostly during summer.
7. Give a brief description of proposed project. When available include any preliminary engineering report or other reports or information that will help explain the project. (Attach sheet if more space is needed)

   Shallow 24" Dia. wells (A), (B), & (C) dug & cased in alluvium to bedrock are proposed for near surface water development for mine operations.

   Storage dam (D) in Ruby Gulch is proposed to retain operations water, act as a settling pond, and be used for recirculation of water.

   Proposed:
   Deep 6" Dia. wells (E) & (F) drilled & cased in Deadwood formation.

Attachments: Attach Form 2A if diversion from a well or dugout, or if storage of water, is proposed. Attach map (see instruction)

STATE OF SOUTH DAKOTA)
County of Pennington)ss

I, DANIEL A FREDLUND the applicant, certify that I have read the foregoing application, have examined the attached map and that the matters therein stated are true and that I intend, and am able to complete the necessary construction.

Signed Daniel A Fredlund

Subscribed and sworn to before me this 21 day of March 1984

Notary Public (or other qualified officer)

Form 2A

Supplemental Information

(type or print in ink)

1. Well Information - Proposed construction

a) Drill Hole Diameter (A) (B) & (C) 24" (E) & (F) 6" Depth (A) 16', (B) 14', (C) 12' (E) 150', (F) 300'

b) Casing Type (A) (B) & (C) Haydite (E) & (F) Steel Diameter 20" 5" Thickness 1&3/4" 1/4"

c) Screen Type none/open hole Diameter 24" & 6" Thickness to be determined

d) Gravel Pack Thickness natural gravel & conglomerate Length of Gravel Pack to be determined

e) Depth to Top of Water Bearing Material unknown

f) Depth of Water (ground surface to water level) unknown

g) Distance to nearest existing domestic well:

On applicants property none On property owned by others est. 3/4 mile

2. Dugout Information Estimates

a) Surface Dimensions _____ Depth _____

b) Depth to water (ground surface to water level) _____

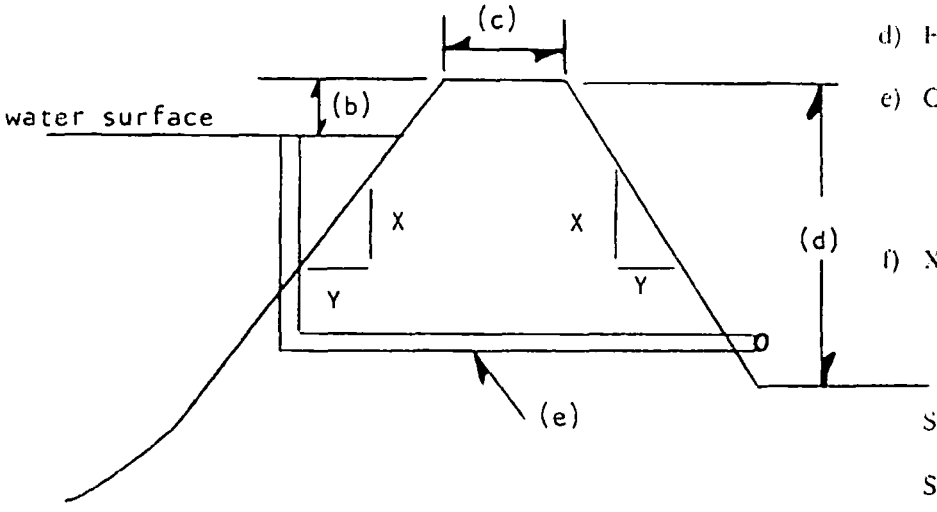
3. Water Storage Dams

If the proposed water use system contains one or more storage dams, please furnish the information requested below. The locations of each dam should be shown on the map submitted with the application.

a) If a private engineering firm or government agency was involved in the design of this dam please give their name and address

_____

_____



b) Freeboard 3'

c) Crest Width 15'

Crest Length 120'

d) Height 5'

e) Outlet Dimensions:
Pipe diameter 20"

Spillway width 40'

f) X & Y Slope
Upstream 1:2

Downstream 1:3

Surface Area of Impoundment 0.23 A

Storage 1.0 acre feet

Drainage area above dam 91 A

Daniel A. Eckhardt

Signature of Applicant

No. _____

NOTICE OF COMPLETION OF WORKS AND/OR APPLICATION OF WATER TO BENEFICIAL USE

Post Office _____

Date _____

TO: Water Rights
Joe Foss Building
Pierre, South Dakota 57501

Dear Sirs:

This is to inform you that I have completed the construction of the water diversion system and/or that I have put the water to beneficial use to maximum extent it is going to be used, not exceeding the amounts as specified in Water Right No. _____.

Water Right Permit No. _____ states that the diversion system is to be constructed by _____, and that the water is put to beneficial use by _____.

The diversion system was completed on _____. Applying the water to beneficial use was completed on _____.

You may schedule an inspection so that ~~the Certificate of Construction and/or~~ the Water License may be issued, thus completing my acquisition of a water right.

_____
(Signature)

Daniel A. Fredlund
Suburban Route Box 307-1
Rapid City, SD 57702

March 21, 1984

Mr. Kevin Larson
Water Rights Division, DWNR
Joe Foss Building
Pierre, SD 57501

Dear Mr. Larson:

Enclosed is my application for permit to appropriate water within the State of South Dakota.

The property is legally described as Lot 8 and Lot 12 of section 5, T4N, R4E of the BHM; Lawrence County, SD. It is located in a dry ravine, and multiple diversion points may be required to obtain water. Therefore, I have proposed three shallow wells, a storage dam, and two deep wells. It is possible that sufficient water may be developed prior to completing all the work described.

If you have any questions, please call me at (605) 348-3763.

Sincerely,

Daniel A. Fredlund

Daniel A. Fredlund

Enc: FORM 2 (two copies)
FORM 2A (two copies)
Map 17x11 signed
Check ($50.00)

FORM 2: Application for uses other than irrigation (type or print)

Mail to: Water Rights Div.
DWNR, Foss Bldg.
Pierre, SD 57501
(605) 773-3352

No._____ Hydrologic Unit _____
Map No. _____ Basin _____
Newspaper _____

Application For Permit To Appropriate Water Within The State Of South Dakota

Check use of water: Industrial ☑ Commercial ☐ Municipal ☐ Other Common Distribution System ☐
Rural Water System ☐ Suburban Housing ☐ Geothermal Heat ☐ Institutional ☐ Recreational ☐
Domestic ☐ (above 18gpm) Other ☐

Type of Application: Check one or more of the following

New ☑ Vested Right ☐ Future Use ☐ Change Use ☐
☐ Amend Permit No._____ with old priority date retained
Change diversion point(s) ☐ Add diversion point(s) ☐ Other ☐ _____
☐ Application to: Change diversion point(s) ☐ Add diversion point(s) ☐ on Permit No. _____
☐ Construction to use water reserved by Future Use Permit No._____

1. Name of Applicant Daniel A. Fredlund Phone No. 348-3763
   Post Office Address Sub. Rt. Box 307-1, Rapid City (Street, RR or Box) State SD 57702 Zip Code
2. Amount of water claimed (c.f.s) 0.10 cfs
3. Source of water supply (Alluvium & basal conglomerate of Deadwood formation) surface and ground water, Lot 8 & Lot 12, Sec 5, T4N, R4E
4. Location of point of diversion (A) 2320'N, 30'W; (B) 1860'N, 150'E; (C) 1450'N, 80'W (D) 1930'N, 530'E; (E) 1750'N; (F) 900'N, 150'W; all from quarter corner Section 5 - Section 8, T4N, R4E, BHM. County Lawrence
5. Counties where water will be used Lawrence
6. Annual period during which water is to be used Year-long, but mostly during summer.
7. Give a brief description of proposed project. When available include any preliminary engineering report or other reports or information that will help explain the project. (Attach sheet if more space is needed)
   Shallow 24" Dia. wells (A), (B), & (C) dug & cased in alluvium to bedrock are proposed for near surface water development for mine operations.
   Storage dam (D) in Ruby Gulch is proposed to retain operations water, act as a settling pond, and be used for recirculation of water.
   Proposed:
   Deep 6" Dia. wells (E) & (F) drilled & cased in Deadwood formation.

Attachments: Attach Form 2A if diversion from a well or dugout, or if storage of water, is proposed. Attach map (see instruction)

STATE OF SOUTH DAKOTA)
County of Pennington)ss

I, DANIEL A. FREDLUND the applicant, certify that I have read the foregoing application, have examined the attached map and that the matters therein stated are true and that I intend, and am able to complete the necessary construction.

Signed Daniel A. Fredlund

Subscribed and sworn to before me this 21 day of March 19 84

_____
Notary Public (or other qualified officer)

Form 2A

Supplemental Information

(type or print in ink)

1. Well Information - Proposed construction

a) Drill Hole Diameter (A) (B) & (C) 24" (E) & (F) 6" Depth (A) 16', (B) 14', (C) 12' (E) 150', (F) 300'

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d) Gravel Pack Thickness natural gravel & conglomerate Length of Gravel Pack to be determined

e) Depth to Top of Water Bearing Material unknown

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On applicants property none On property owned by others est. 3/4 mile

2. Dugout Information Estimates

a) Surface Dimensions _____ Depth _____

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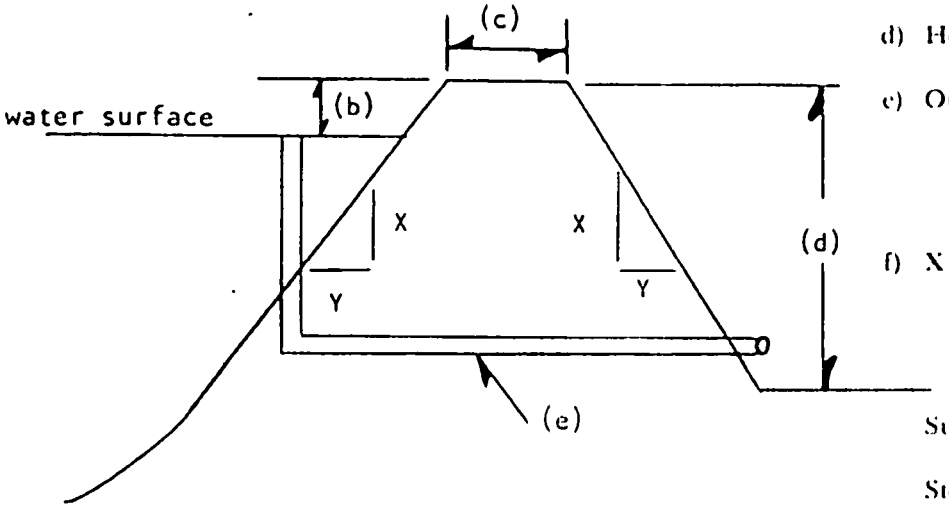
If the proposed water use system contains one or more storage dams, please furnish the information requested below. The locations of each dam should be shown on the map submitted with the application.

a) If a private engineering firm or government agency was involved in the design of this dam please give their name and address

_____

_____



b) Freeboard 3'

c) Crest Width 15'

Crest Length 120'

d) Height 5'

e) Outlet Dimensions:
Pipe diameter 20"

Spillway width 40'

f) X & Y Slope
Upstream 1:2

Downstream 1:3

Surface Area of Impoundment 0.23 A

Storage 1.0 acre feet

Drainage area above dam 91 A

Daniel A. Fuhrmann

Signature of Applicant

INSTRUCTIONS FOR
APPLICATION FOR A WATER PERMIT AND/OR RIGHT

Revised 7-83

A completed application for a water permit and/or water right must include the following:

1. TWO COMPLETED COPIES OF FORM 2, Application to appropriate water.

2. A map, not smaller than 8" x 11", showing:
   a) The location of the diversion point (place where water is to be taken from) in relation to a government section corner or quarter corner by direction and distance.
   b) If diversion is from a reservoir, the location of the high water line and lands under water, with the names of the owner's (if other than the applicant) and the capacity of the reservoir at maximum pool elevation.
   c) If diversion is from a stream the location and name of the stream.
   d) Lands to be irrigated and names of the owners (if other than the applicant).
   e) The map must be signed by one of the following: Registered Land Surveyor, Registered Professional Engineer or by any other government employee who normally prepares maps as part of his assigned duties (SCS, ASCS, etc.)

3. If diversion is from a well, dugout or storage dam, two completed copies of Form 2A must be submitted with Form 2. Also provide any supplemental plans or drawings for any storage reservoir. If diversion is from a well, a well log or driller's test log signed by a South Dakota licensed well driller MUST accompany the application. If the well is to be completed into a formation below the Greenhorn an estimate of the depth of the well, proposed construction of the well and formations encountered can be submitted in lieu of a test hole log. When the well is constructed the drillers log of the completed well must be submitted to this office within 30 days of completion.

4. According to South Dakota Statutes the following filing fees are required for each application:

   First 120 acre feet per year or for irrigating the first 60 acres = $150.00
   Second 120 acre feet or second 60 acres = 75.00
   Each additional 120 acre feet or each additional 60 acres = 25.00

   Example: Filing fee for irrigating 160 acres would be $250.00
   Filing fee for continuous use for 223 gpm (.479 cfs or 360 AF/yr) would be $250.00 (1.0 cfs = 449 gpm)

   To appropriate 0.10 cfs or less, to change a diversion point or add a diversion point (on an existing permit) with no new appropriation of water = $50.00

The fee for filing a future use permit application is 10% of the calculated fee for the amount of water applied for. If after the seven year review the permit is granted an extension, another 10% filing fee is required. When an application for part or all of the reserved water under a future use is received the applicable fees must be paid.

The forms, signed map, fees and any other pertinent information for filing a Water Permit Application should be submitted to: Water Rights Division, DWNR
Joe Foss Building
Pierre, South Dakota 57501 (605) 773-3352

5. Notice of an application must be published in one local county newspaper for two successive weeks with second publication at least 30 days before Water Management Board Meeting. Publication notice will be sent to newspaper by Water Rights Div.

6. State Statutes require that a Soil/Water Compatibility permit for groundwater and surface water be obtained from the Dept. of Agriculature if the water is to be used for irrigation. This must be obtained and forwarded to the Div. of Water Rights before the Water Permit Application can be advertised for a public hearing and considered by the Water Management Board. For procedures and required forms, contact the Division of Conservation, Department of Agriculture, Anderson Building, Pierre, South Dakota 57501 (605) 773-3259.

7. Upon completion of the construction of the system and the application of water to beneficial use an inspection will be conducted. The fee for the inspection is $50.00. After the inspection and payment of the fee a Water License will be issued. The issuance of the Water License is the final action for obtaining a water right.

APPENDIX 2.
(WATSTORE 4/84)

MADISON AQUIFER

DESCRIPTIVE STATISTICS OF WATER QUALITY PARAMETERS
BASED ON LATEST WATER QUALITY SAMPLES COLLECTED

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	STD ERROR OF MEAN	MINIMUM VALUE	MAXIMUM VALUE
P72008	DEPTH OF WELL, TOTAL (FEET)	24	2821.21	1550.37	316.47	550.00	5450.00
P00010	TEMPERATURE (DEG C)	41	22.79	16.87	2.63	7.00	63.00
P00300	OXYGEN, DISSOLVED (MG/L)	20	7.20	2.65	0.59	2.20	11.00
P00095	SPECIFIC CONDUCTANCE (UMHOS)	45	897.76	809.82	120.72	210.00	3140.00
P00400	PH (STANDARD UNITS)	67	7.46	0.33	0.04	6.77	8.50
P70300	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED	50	945.68	814.36	115.17	182.00	2750.00
P70301	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (	17	1084.82	906.74	219.92	195.00	2630.00
P00900	HARDNESS (MG/L AS CACO3)	84	510.63	442.99	48.33	7.00	1800.00
P00902	HARDNESS, NONCARBONATE (MG/L CACO3)	69	282.78	442.78	53.30	0.00	1680.00
P00410	ALKALINITY FIELD (MG/L AS CACO3)	41	205.91	61.53	9.61	90.00	359.00
P00915	CALCIUM DISSOLVED (MG/L AS CA)	79	137.75	137.08	15.42	1.00	550.00
P00925	MAGNESIUM, DISSOLVED (MG/L AS MG)	80	39.04	26.51	2.96	1.00	110.00
P00930	SODIUM, DISSOLVED (MG/L AS NA)	75	36.00	66.63	7.69	0.20	330.00
P00931	SODIUM ADSORPTION RATIO	73	0.71	1.35	0.16	0.00	5.90
P00935	POTASSIUM, DISSOLVED (MG/L AS K)	46	10.47	11.47	1.69	0.50	44.40
P00937	POTASSIUM, TOTAL RECOVERABLE (MG/L AS K)	20	3.57	5.38	1.20	0.10	22.00
P00440	BICARBONATE FET-FLD (MG/L AS HCO3)	53	247.42	70.49	9.68	110.00	436.00
P90440	BICARBONATE IT-LAB (MG-L HCO3)	15	218.47	54.59	14.10	149.00	337.00
P00445	CARBONATE FET-FLD (MG/L AS CO3)	33	1.89	6.27	1.09	0.00	36.00
P90445	CARBONATE IT-LAB (MG/L CO3)	0	.	.	.	.	.
P00945	SULFATE DISSOLVED (MG/L AS SO4)	79	326.90	474.28	53.36	1.00	1700.00
P00940	CHLORIDE, DISSOLVED (MG/L AS CL)	75	44.93	77.41	8.94	0.00	340.00
P00950	FLUORIDE, DISSOLVED (MG/L AS F)	45	1.33	1.22	0.18	0.10	4.30
P00618	NITROGEN, NITRATE DISSOLVED (MG/L AS N)	1	0.13	.	.	0.13	0.13
P00620	NITROGEN, NITRATE TOTAL (MG/L AS N)	35	0.81	1.53	0.26	0.00	8.00
P00665	PHOSPHORUS, TOTAL (MG/L AS P)	20	0.04	0.01	0.00	0.04	0.10
P01022	BORON, TOTAL RECOVERABLE (UG/L AS B)	20	50.15	87.49	19.56	9.00	389.00
P01020	BORON, DISSOLVED (UG/L AS B)	17	128.24	168.38	40.84	0.00	630.00
P01046	IRON, DISSOLVED (UG/L AS FE)	13	1657.69	2561.21	710.35	10.00	7900.00
P01045	IRON, TOTAL RECOVERABLE (UG/L AS FE)	53	329.19	879.92	120.87	0.00	5100.00
P01056	MANGANESE, DISSOLVED (UG/L AS MN)	13	41.69	48.43	13.43	1.00	150.00
P01055	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN	49	30.94	64.94	9.28	0.00	290.00
P01145	SELENIUM, DISSOLVED (UG/L AS SE)	14	2.36	2.90	0.77	1.00	10.00
P01147	SELENIUM, TOTAL (UG/L AS SE)	25	0.96	1.52	0.30	0.20	6.40
P00955	SILICA, DISSOLVED (MG/L AS SIO2)	38	12.69	10.43	1.69	0.10	39.00
P01105	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL)	22	26.45	59.78	12.75	10.00	280.00
P01000	ARSENIC DISSOLVED (UG/L AS AS)	12	3.08	2.68	0.77	1.00	11.00
P01002	ARSENIC TOTAL (UG/L AS AS)	26	3.71	5.54	1.09	0.50	27.00
P01005	BARIUM, DISSOLVED (UG/L AS BA)	14	112.14	67.27	17.98	0.00	300.00
P01007	BARIUM, TOTAL RECOVERABLE (UG/L AS BA)	26	59.08	57.23	11.22	0.04	237.00
P01025	CADMIUM DISSOLVED (UG/L AS CD)	15	0.87	0.99	0.26	0.00	2.00
P01027	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	5	1.00	0.00	0.00	1.00	1.00
P01030	CHROMIUM, DISSOLVED (UG/L AS CR)	14	8.57	10.27	2.75	0.00	20.00
P01034	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	25	3.80	1.65	0.33	1.00	10.00
P01037	COBALT, TOTAL RECOVERABLE (UG/L AS CO)	20	2.55	1.28	0.29	2.00	7.00
P01042	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	32	13.22	25.08	4.43	0.03	134.00
P01051	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	5	1.26	0.40	0.18	1.00	1.90
P01132	LITHIUM TOTAL RECOVERABLE (UG/L AS LI)	21	25.33	54.99	12.00	2.00	236.00
P71890	MERCURY DISSOLVED (UG/L AS HG)	12	0.45	0.94	0.27	0.00	3.40
P71900	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	6	0.55	0.72	0.29	0.20	2.00
P01062	MOLYBDENUM, TOTAL RECOVERABLE (UG/L AS M	20	7.25	7.28	1.63	4.00	34.00
P01067	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	20	4.85	3.36	0.75	4.00	19.00

APPENDIX 2.
(WATSTORE 4/84)

MADISON AQUIFER

DESCRIPTIVE STATISTICS OF WATER QUALITY PARAMETERS
BASED ON LATEST WATER QUALITY SAMPLES COLLECTED

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	STD ERROR OF MEAN	MINIMUM VALUE	MAXIMUM VALUE
P01075	SILVER, DISSOLVED (UG/L AS AG)	0	.	.	.	.	.
P01077	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	25	1.96	0.88	0.14	1.00	4.00
P82364	THORIUM TOTAL (UG/L AS TH)	20	8.00	5.30	1.19	5.00	22.00
P01152	TITANIUM, TOTAL (UG/L AS TI)	20	2.40	1.74	0.40	2.00	10.00
P28011	URANIUM NATURAL TOTAL (UG/L AS U)	20	4.89	6.34	1.88	0.68	39.00
P80029	GROSS ALPHA TOTAL (UG/L AS U NATRL)	3	6.39	4.44	2.56	1.33	9.63
P01087	VANADIUM, TOTAL (UG/L AS V)	20	6.85	10.10	2.26	4.00	49.00
P01092	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	31	169.15	301.03	54.07	1.50	1407.00
P01162	ZIRCONIUM, TOTAL (UG/L AS ZR)	20	2.15	0.49	0.11	2.00	4.00
P28401	CERIUM 144, TOTAL (PCI/L)	20	35.10	18.14	4.06	30.00	109.00
P09510	RA-226, DISSOLVED, PLANCHET COUNT (PCI/L	4	39.20	75.21	37.60	0.40	152.00
P01049	LEAD, DISSOLVED (UG/L AS PB)	15	1.40	1.64	0.42	0.00	4.00

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P00410	ALKALINITY FIELD (MG/L AS CACO3)	41	205.91	61.53	9.61	90.00	359.00
P00915	CALCIUM DISSOLVED (MG/L AS CA)	79	137.75	137.08	15.42	1.00	550.00
P00925	MAGNESIUM, DISSOLVED (MG/L AS MG)	80	39.04	26.51	2.96	1.00	110.00
P00930	SODIUM, DISSOLVED (MG/L AS NA)	75	38.00	66.63	7.69	0.20	330.00
P00931	SODIUM ADSORPTION RATIO	73	0.71	1.35	0.16	0.00	5.90
P00935	POTASSIUM, DISSOLVED (MG/L AS K)	46	10.47	11.47	1.69	0.50	44.40
P00937	POTASSIUM, TOTAL RECOVERABLE (MG/L AS K)	20	3.57	5.38	1.20	0.10	22.00
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P90440	BICARBONATE IT-LAB (MG-L HCO3)	15	218.47	54.59	14.10	149.00	337.00
P00445	CARBONATE FET-FLD (MG/L AS CO3)	33	1.09	6.27	1.09	0.00	36.00
P90445	CARBONATE IT-LAB (MG/L CO3)	0	.	.	.	.	.
P00945	SULFATE DISSOLVED (MG/L AS SO4)	79	326.90	474.28	53.36	1.00	1700.00
P00940	CHLORIDE, DISSOLVED (MG/L AS CL)	75	44.93	77.41	8.94	0.00	340.00
P00950	FLUORIDE, DISSOLVED (MG/L AS F)	45	1.33	1.22	0.18	0.10	4.30
P00618	NITROGEN, NITRATE DISSOLVED (MG/L AS N)	1	0.13	.	.	0.13	0.13
P00620	NITROGEN, NITRATE TOTAL (MG/L AS N)	35	0.81	1.53	0.26	0.00	8.00
P00665	PHOSPHORUS, TOTAL (MG/L AS P)	20	0.04	0.01	0.00	0.04	0.10
P01022	BORON, TOTAL RECOVERABLE (UG/L AS B)	20	50.15	87.49	19.56	9.00	389.00
P01020	BORON, DISSOLVED (UG/L AS B)	17	128.24	168.38	40.84	0.00	630.00
P01046	IRON, DISSOLVED (UG/L AS FE)	13	1657.69	2561.21	710.35	10.00	7900.00
P01045	IRON, TOTAL RECOVERABLE (UG/L AS FE)	53	329.19	879.92	120.87	0.00	5100.00
P01056	MANGANESE, DISSOLVED (UG/L AS MN)	13	41.69	48.43	13.43	1.00	150.00
P01055	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN	49	30.94	64.94	9.28	0.00	290.00
P01145	SELENIUM, DISSOLVED (UG/L AS SE)	14	2.36	2.90	0.77	1.00	10.00
P01147	SELENIUM, TOTAL (UG/L AS SE)	25	0.96	1.52	0.30	0.20	6.40
P00955	SILICA, DISSOLVED (MG/L AS SIO2)	38	12.69	10.43	1.69	0.10	39.00
P01105	ALUMINUM, TOTAL RECOVERABLE (UG/L AS AL)	22	26.45	59.78	12.75	10.00	280.00
P01000	ARSENIC DISSOLVED (UG/L AS AS)	12	3.08	2.68	0.77	1.00	11.00
P01002	ARSENIC TOTAL (UG/L AS AS)	26	3.71	5.54	1.09	0.50	27.00
P01005	BARIUM, DISSOLVED (UG/L AS BA)	14	112.14	67.27	17.98	0.00	300.00
P01007	BARIUM, TOTAL RECOVERABLE (UG/L AS BA)	26	59.08	57.23	11.22	0.04	237.00
P01025	CADMIUM DISSOLVED (UG/L AS CD)	15	0.87	0.99	0.26	0.00	2.00
P01027	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	5	1.00	0.00	0.00	1.00	1.00
P01030	CHROMIUM, DISSOLVED (UG/L AS CR)	14	8.57	10.27	2.75	0.00	20.00
P01034	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	25	3.80	1.65	0.33	1.00	10.00
P01037	COBALT, TOTAL RECOVERABLE (UG/L AS CO)	20	2.55	1.28	0.29	2.00	7.00
P01042	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	32	13.22	25.08	4.43	0.03	134.00
P01051	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	5	1.26	0.40	0.18	1.00	1.90
P01132	LITHIUM TOTAL RECOVERABLE (UG/L AS LI)	21	25.33	54.99	12.00	2.00	236.00
P71890	MERCURY DISSOLVED (UG/L AS HG)	12	0.45	0.94	0.27	0.00	3.40
P71900	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	6	0.55	0.72	0.29	0.20	2.00
P01062	MOLYBDENUM, TOTAL RECOVERABLE (UG/L AS M	20	7.25	7.28	1.63	4.00	34.00
P01067	NICKEL, TOTAL RECOVERABLE (UG/L AS NI)	20	4.85	3.36	0.75	4.00	19.00

APPENDIX 2.
(WATSTORE 4/84)

MADISON AQUIFER

DESCRIPTIVE STATISTICS OF WATER QUALITY PARAMETERS
BASED ON LATEST WATER QUALITY SAMPLES COLLECTED

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	STD ERROR OF MEAN	MINIMUM VALUE	MAXIMUM VALUE
P01075	SILVER, DISSOLVED (UG/L AS AG)	0	.	.	.	.	.
P01077	SILVER, TOTAL RECOVERABLE (UG/L AS AG)	25	1.96	0.68	0.14	1.00	4.00
P82364	THORIUM TOTAL (UG/L AS Th)	20	8.00	5.30	1.19	5.00	22.00
P01152	TITANIUM, TOTAL (UG/L AS Ti)	20	2.40	1.79	0.40	2.00	10.00
P28011	URANIUM NATURAL TOTAL (UG/L AS U)	20	4.89	8.39	1.88	0.68	39.00
P80029	GROSS ALPHA TOTAL (UG/L AS U NATNL)	3	6.39	4.44	2.56	1.33	9.63
P01087	VANADIUM, TOTAL (UG/L AS V)	20	6.85	10.10	2.26	4.00	49.00
P01092	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	31	169.15	301.03	54.07	1.50	1407.00
P01162	ZIRCONIUM, TOTAL (UG/L AS ZR)	20	2.15	0.49	0.11	2.00	4.00
P28901	CERIUM 140, TOTAL (PCI/L)	20	35.10	18.14	4.06	30.00	109.00
P09510	RA-226, DISSOLVED, PLANCHET COUNT (PCI/L	4	59.20	75.21	37.60	0.40	152.00
P01049	LEAD, DISSOLVED (UG/L AS PB)	15	1.40	1.64	0.42	0.00	4.00

Description	Unit	meq/l #	M1	M2	M3	M4	M5	M6	M7	M8	M8	M9
Date			08-Oct-79	18-Oct-79	08-Oct-79	10-Aug-78	08-Oct-79	1940	14-Nov-83	21-Jul-78	28-Aug-79	18-Oct-79
Time			0105	0105	0105		0105	0100		0900		0105
Station Number	latitude/longitude		441749103515701	442024103545701	442027103501301	442217103272201	442240103301001	442440103285501	442503103391801	442504103415301	442504103415301	442822103534501
ABC Number	(M=Madison)		M1	M2	M3	M4	M5	M6	M7	M8	M8	M9
GENERAL												
X Coordinate	feet		988744	976673	997050	1095931	1209472	1090033	1045493	1034386	1034386	984407
Y Coordinate	feet		193381	209778	209049	215232	211812	230094	234696	235362	235362	258062
Elevation of Land Surface Datum	feet above NGVD		5330	6321	6400	3625	3750	3335	3960	4360	4360	4226
Total Depth of Well	feet		26.2	72.2	49.2	1465	29.5	1800		550	550	984
Collecting Agency	code number		84610	84610	84610		84610	46004	1028			84610
Analyzing Agency	code number		84610	84610	84610	80020	84610	46004	80020	80020	800200	84610
FIELD DATA												
pH	su		7.6	7.9	8	7.3	7.6		7.4	7.21		7.5
Alkalinity (field)	mg/l as CaCO3		320	220	170	221	138			277		240
Bicarbonate (field)	mg/l as HCO3	0.01639	390	270	210	270	170	260		340		300
Carbonate (field)	mg/l as CO3	0.03333	0	0	0	0	0			0		0
Hardness, Total fld Noncarb	mg/l as CaCO3		0	7	0	12	0	540	15	200		7
Specific Conductance	us/cm		560	460	450	440	210		570	828		510
GENERAL PARAMETERS												
Water Temperature	degrees C		11.5	8	14.5	12.5	9	10	7	10.5		13
pH Lab	su								7.4			
Alkalinity, Lab	mg/l as CaCO3											
Alkalinity, Methyl Orange	mg/l											
Dissolved Carbon Dioxide	mg/l as CO2		16	5.5	3.3	22	6.9		19	33		15
Dissolved Organic Carbon	mg/l as C					0.5				1.1		
Dissolved Oxygen	mg/l		4.7	9.5	2.5		2.6					9.3
Dissolved Residue	mg/l @ 105 deg C					325				630		
Total Suspended Residue	mg/l @ 105 deg C					-1				-1		
Dissolved Solids	tons/ac-ft					0.31			0.36	0.78		
Dissolved Solids Residue	mg/l @ 180 deg C					226		1060	265	571		
Diss. Solids, Sum of Constituents	mg/l					238			267	544		
Hardness, Total	mg/l as CaCO3		290	230	150	230	7	760	260	480		250
Sodium Adsorption Ratio			0.1	0	0.1	0.1	0		0	0.1		0
Sodium Percent						2			1	3		
Specific Conductance, Lab	us/cm								447			
MAJOR CATIONS												
Calcium, Dissolved	mg/l as Ca	0.04990	60	43	43	55	1	210	79	88		56
Magnesium, Dissolved	mg/l as Mg	0.08226	34	29	11	23	1	56	15	63		26
Sodium, Dissolved	mg/l as Na	0.04350	3.1	1.6	4.1	2.3	0.2		1.5	5.8		1
Potassium, Dissolved	mg/l as K	0.02557				1.3			1.2	3.6		
Potassium, Total Recoverable	mg/l as K	0.02557	1.4	1.5	0.7		0.1					1.1
MAJOR ANIONS												
Bicarbonate, IT-lab	mg-l HCO3	0.01639										
Bicarbonate (field)	mg/l as HCO3	0.01639	390	270	210	270	170	260		340		300
Carbonate (field)	mg/l as CO3	0.03333	0	0	0	0	0			0		0
Chloride, Dissolved	mg/l as Cl	0.02821	-10	-10	-10	1.8	-10		1.1	3.9		-10
Sulfate, Dissolved	mg/l as SO4	0.02082	-5	-5	7	11	17	600	13	200		-5
Fluoride, Dissolved	mg/l as F	0.05264				0.3		0.7	0.1	0.2		

Ref: 1182/900201

Description	Unit	meq/l #	M1	M2	M3	M4	M5	M6	M7	M8	M8	M9
ION BALANCE												
Total Cations	meq/l		5.96	4.64	3.25	4.77	0.14	15.09	5.27	9.92		5.00
Total Anions	meq/l		6.39	4.43	3.59	4.72	3.14	16.79	0.31	9.86		4.92
Ion Balance	(cations-anions/sum)		-3.49%	2.36%	-4.99%	0.52%	-91.26%	-5.35%	89.00%	0.31%		0.88%
DISSOLVED SPECIES												
Aluminum, Dissolved	ug/l as Al					-100				20		
Arsenic, Dissolved	ug/l as As					2				1		
Barium, Dissolved	ug/l as Ba					300				50		
Boron, Dissolved	ug/l as B					-20				-20		
Bromide, Dissolved	mg/l as Br					0				0		
Cadmium, Dissolved	ug/l as Cd					-2				3	ND	
Chromium, Dissolved	ug/l as Cr					ND				ND		
Copper, Dissolved	ug/l as Cu					2				-2		
Iodine, Dissolved	mg/l as I					0				0		
Iron, Dissolved	ug/l Fe					20				-10		
Lead, Dissolved	ug/l as Pb					3				29	ND	
Lithium, Dissolved	ug/l as Li					-4				7		
Manganese, Dissolved	ug/l as Mn					5				3		
Mercury, Dissolved	ug/l as Hg					0.3				-0.1		
Molybdenum, Dissolved	ug/l as Mo					7				1		
Nitrogen, Ammonia Dissolved	mg/l as NH4											
Nitrogen, Nitrate Dissolved	mg/l as NO3											
Nitrogen, Nitrate Dissolved	mg/l as N											
Nitrogen, Nitrite Dissolved	mg/l as NO2											
Nitrogen, NO2+NO3 Dissolved	mg/l as N											
Nitrogen Nitrite, Dissolved	mg/l as N											
Phosphorous, Dissolved	mg/l as P					0.01				-0.01		
Selenium, Dissolved	ug/l as Se					3				1		
Silica, Dissolved	mg/l as SiO2		4.1	4.2	5.5	10	0.1		9.5	12		4.6
Strontium, Dissolved	ug/l as Sr					330				500		
Uranium, Natural Dissolved	ug/l as U											
Vanadium, Dissolved	ug/l as V					1				0		
Zinc, Dissolved	ug/l as Zn					20				590		
TOTAL SPECIES												
Aluminum, Total Recoverable	ug/l as Al		-10	-10	-10		-10					-10
Arsenic, Total	ug/l as As		0	0	4		0		3			1
Barium, Total Recoverable	ug/l as Ba		50	20	30		10					50
Boron, Total Recoverable	ug/l as B		20	20	9		170					10
Chromium, Total Recoverable	ug/l as Cr		-4	-4	-4		10					-4
Cobalt, Total Recoverable	ug/l as Co		-2	-2	3		3					-2
Copper, Total Recoverable	ug/l as Cu		2	-2	130		4					5
Cyanide, Total	mg/l as CN								-0.01		0.01	
Iron, Total Recoverable	ug/l as Fe		20	20	10		-10	1700				10
Lithium, Total Recoverable	ug/l as Li		5	4	3		2					3
Manganese, Total Recoverable	ug/l as Mn		2	-2	-2		2					4
Molybdenum, Total Recoverable	ug/l as Mo		4	-4	6		7					-4
Nickel, Total Recoverable	ug/l as Ni		-4	-4	-4		19					-4
Nitrogen, Ammonia Total	mg/l as NH4											
Nitrogen, Ammonia+Organic Total	mg/l as N					0.08				0.17		
Nitrogen, Nitrate Total	mg/l as N							3.3				

Description	Unit	meq/l #	M1	M2	M3	M4	M5	M6	M7	M8	M8	M9
Nitrogen, Nitrite Total	mg/l as N											
Nitrogen, NO2+NO3 Total	mg/l as N											
Nitrogen, Total	mg/l as NO3											
Nitrogen, Total	mg/l as N											
Nitrogen, Total Organic	mg/l as N											
Phosphorous, Total	mg/l as P		-0.04	-0.04	0.057		-0.04					-0.04
Scandium, Total	ug/l as Sc						6					
Selenium, Total	ug/l as Se		0	0	0		1					0
Silver, Total Recoverable	ug/l as Ag		-2	-2	-2		-2					-2
Strontium, Total Recoverable	ug/l as Sr		80	100	80		5					130
Sulfide, Total	mg/l as S					0.2				0.5		
Thorium, Total	ug/l as Th		-5	-5	-5		-5					-5
Titanium, Total	ug/l as Ti		-2	-2	-2		10					-2
Uranium, Natural Total	ug/l as U		3.2	1.2	0.86		1.2					2
Vanadium, Total	ug/l as V		-4	-4	-4		49					-4
Zinc, Total Recoverable	ug/l as Zn		90	120	290		40					770
Zirconium, Total	ug/l as Zr		-2	-2	-2		-2					-2
RADIONUCLIDES												
Cerium 144, Total	pCi/l		30	-30	-30		-30					-30
Gross Alpha, Dissolved	pCi/l as U-nat					12				-3		
Gross Alpha, Dissolved	ug/l as U-nat					18				-4.4		
Gross Alpha, Total Suspended	pCi/l as U-nat					-0.3				-0.3		
Gross Alpha, Total Suspended	ug/l as U-nat					-0.4				-0.4		
Gross Beta, Dissolved	pCi/l, as Cs-137					3.2				3.6		
Gross Beta, Dissolved	pCi/l as Sr/Yt-90					3				3.3		
Gross Beta, Total Suspended	pCi/l as Sr/Yt-90					0.6				-0.4		
Gross Beta, Total Suspended	pCi/l as Cs-137					0.5				-0.4		
Radium 226, Dissolved	Radon Method, pCi/l											

Ref: 1182/900201

Description	Unit	meq/l @	M10	M11	M12	M13	M13	M14	M14	M14	M15	M16
Date			04-Dec-81	02-May-80	14-Sep-79	01-Mar-74	27-Jan-79	28-Aug-80	09-Nov-80	22-Oct-80	11-Mar-81	08-Sep-79
Time			0100	0100	0105	0100	0100	0100	0100		0100	0105
Station Number	latitude/longitude		443148103534001	443210104021601	443227103503401	443511103575801	443511103575801	443716103522501	443716103522501	443716103522501	444114103323901	444116103510301
ABC Number	(M=Madison)		M10	M11	M12	M13	M13	M14	M14	M14	M15	M16
GENERAL												
X Coordinate	feet		985874	948999	999418	968469	968469	993015	993015	993015	1079323	1000186
Y Coordinate	feet		278965	283077	282249	300521	300521	312004	312004	312004	331860	336080
Elevation of Land Surface Datum	feet above NGVD		3510	3581	3382	3380	3380	3242	3242	3242	2835	3035
Total Depth of Well	feet		1125	840	496	1426	1426	2220	2220	2220	3930	698
Collecting Agency	code number		1028	1028	84610	1028	1028	46004	46004	80020	1028	84610
Analyzing Agency	code number		1028	1028	84610	1028	1028	46004	46004	80020	1028	84610
FIELD DATA												
pH	su		7.38	7.28	7.2	7.42	7.08			6.79	7.49	8.5
Alkalinity (field)	mg/l as CaCO3				282					236		187
Bicarbonate (field)	mg/l as HCO3	0.01639			350	240	260			290	240	240
Carbonate (field)	mg/l as CO3	0.03333			0							11
Hardness, Total fld Noncarb	mg/l as CaCO3		160	120	340	650	98	240	240	0	150	0
Specific Conductance	us/cm				945	1560	589			458	470	890
GENERAL PARAMETERS												
Water Temperature	degrees C				12.5			22		21.5		17.5
pH Lab	su									7.4		
Alkalinity, Lab	mg/l as CaCO3											
Alkalinity, Methyl Orange	mg/l											
Dissolved Carbon Dioxide	mg/l as CO2		17	23	35	15	34				12	1.2
Dissolved Organic Carbon	mg/l as C									3.6		
Dissolved Oxygen	mg/l				11							1.9
Dissolved Residue	mg/l @ 105 deg C											
Total Suspended Residue	mg/l @ 105 deg C											
Dissolved Solids	tons/ac-ft		0.54	0.49		1.7	0.48			0.31	0.54	
Dissolved Solids Residue	mg/l @ 180 deg C							220	190	228		
Diss. Solids, Sum of Constituents	mg/l		395	357		1250	356			244	397	
Hardness, Total	mg/l as CaCO3		370	340	620	840	310	240	240	230	350	22
Sodium Adsorption Ratio			0	0	0.1	0	0		0.1	0	0.1	19
Sodium Percent			1	1		0	1			2	3	
Specific Conductance, Lab	us/cm		650	608				489	437	446		
MAJOR CATIONS												
Calcium, Dissolved	mg/l as Ca	0.04990	92	98	170	250	82	54	55	54	96	5.6
Magnesium, Dissolved	mg/l as Mg	0.08226	34	23	48	53	26	25	24	23	26	2
Sodium, Dissolved	mg/l as Na	0.04350	2	2	5.4	2	2	-5	2	1.8	5	190
Potassium, Dissolved	mg/l as K	0.02557	1	1		2	1			1.1	1	
Potassium, Total Recoverable	mg/l as K	0.02557			2							2.9
MAJOR ANIONS												
Bicarbonate, IT-lab	mg-l HCO3	0.01639	259	273								
Bicarbonate (field)	mg/l as HCO3	0.01639			350	240	260			290	240	240
Carbonate (field)	mg/l as CO3	0.03333			0							11
Chloride, Dissolved	mg/l as Cl	0.02821	4	3	-10	3	3	-2	-2	1.3	9	-10
Sulfate, Dissolved	mg/l as SO4	0.02082	130	96	430	820	110	30	11	8.3	140	210
Fluoride, Dissolved	mg/l as F	0.05264						0.28	0.27	0.4		

Description	Unit	meq/l #	M10	M11	M12	M13	M13	M14	M14	M14	M15	M16
Nitrogen, Nitrite Total	mg/l as N									0		
Nitrogen, NO2+NO3 Total	mg/l as N									0.15		
Nitrogen, Total	mg/l as NO3									1.2		
Nitrogen, Total	mg/l as N									0.27		
Nitrogen, Total Organic	mg/l as N									0.1		
Phosphorous, Total	mg/l as P				-0.04							-0.04
Scandium, Total	ug/l as Sc											
Selenium, Total	ug/l as Se				0							0
Silver, Total Recoverable	ug/l as Ag				-2							-2
Strontium, Total Recoverable	ug/l as Sr				2300							130
Sulfide, Total	mg/l as S									0		
Thorium, Total	ug/l as Th				-5							-5
Titanium, Total	ug/l as Ti				-2							-2
Uranium, Natural Total	ug/l as U				3.9							0.57
Vanadium, Total	ug/l as V				-4							4
Zinc, Total Recoverable	ug/l as Zn				6							6
Zirconium, Total	ug/l as Zr				-2							-2
RADIONUCLIDES												
Cerium 144, Total	pCi/l											
Gross Alpha, Dissolved	pCi/l as U-nat				-30							-30
Gross Alpha, Dissolved	ug/l as U-nat									14		
Gross Alpha, Total Suspended	pCi/l as U-nat									20		
Gross Alpha, Total Suspended	ug/l as U-nat											
Gross Beta, Dissolved	pCi/l, as Cs-137									4.4		
Gross Beta, Dissolved	pCi/l as Sr/Yt-90									4		
Gross Beta, Total Suspended	pCi/l as Sr/Yt-90											
Gross Beta, Total Suspended	pCi/l as Cs-137											
Radium 226, Dissolved	Radon Method, pCi/l									1.3		

Description	Unit	meq/l *	M10	M11	M12	M13	M13	M14	M14	M14	M15	M16
ION BALANCE												
Total Cations	meq/l		7.50	6.89	12.72	16.97	6.34	4.75	4.81	4.69	7.17	8.78
Total Anions	meq/l		7.06	6.56	14.69	21.09	6.64	0.64	0.24	4.98	7.10	8.67
Ion Balance	(cations-anions/sum)		2.99%	2.50%	-7.19%	-10.82%	-2.26%	76.28%	90.37%	-3.00%	0.49%	0.63%
DISSOLVED SPECIES												
Aluminum, Dissolved	ug/l as Al									20		
Arsenic, Dissolved	ug/l as As									4		
Barium, Dissolved	ug/l as Ba									200		
Boron, Dissolved	ug/l as B		20							0		
Bromide, Dissolved	mg/l as Br									0		
Cadmium, Dissolved	ug/l as Cd									-1		
Chromium, Dissolved	ug/l as Cr									0		
Copper, Dissolved	ug/l as Cu											
Iodine, Dissolved	mg/l as I									0		
Iron, Dissolved	ug/l Fe									20		
Lead, Dissolved	ug/l as Pb									3		
Lithium, Dissolved	ug/l as Li									6		
Manganese, Dissolved	ug/l as Mn									-1		
Mercury, Dissolved	ug/l as Hg									0		
Molybdenum, Dissolved	ug/l as Mo									-10		
Nitrogen, Ammonia Dissolved	mg/l as NH4									0		
Nitrogen, Nitrate Dissolved	mg/l as NO3									0.58		
Nitrogen, Nitrate Dissolved	mg/l as N									0.13		
Nitrogen, Nitrite Dissolved	mg/l as NO2									0		
Nitrogen, NO2+NO3 Dissolved	mg/l as N									0.13		
Nitrogen Nitrite, Dissolved	mg/l as N									0		
Phosphorous, Dissolved	mg/l as P									0.22		
Selenium, Dissolved	ug/l as Se									1		0
Silica, Dissolved	mg/l as SiO2		5.2							11		3.6
Strontium, Dissolved	ug/l as Sr									320		
Uranium, Natural Dissolved	ug/l as U									3.7		
Vanadium, Dissolved	ug/l as V									1		
Zinc, Dissolved	ug/l as Zn									20		
TOTAL SPECIES												
Aluminum, Total Recoverable	ug/l as Al		-10									10
Arsenic, Total	ug/l as As		1									0
Barium, Total Recoverable	ug/l as Ba		20									10
Boron, Total Recoverable	ug/l as B		60									30
Chromium, Total Recoverable	ug/l as Cr		-4									-4
Cobalt, Total Recoverable	ug/l as Co		2									3
Copper, Total Recoverable	ug/l as Cu		3									-2
Cyanide, Total	mg/l as CN											
Iron, Total Recoverable	ug/l as Fe		20			-50	-50					20
Lithium, Total Recoverable	ug/l as Li		10									100
Manganese, Total Recoverable	ug/l as Mn		2			-50	-50				-2	
Molybdenum, Total Recoverable	ug/l as Mo		-4									7
Nickel, Total Recoverable	ug/l as Ni		-4									-4
Nitrogen, Ammonia Total	mg/l as NH4									0.02		
Nitrogen, Ammonia+Organic Total	mg/l as N									0.12		
Nitrogen, Nitrate Total	mg/l as N					-0.1	-0.1			0.15		

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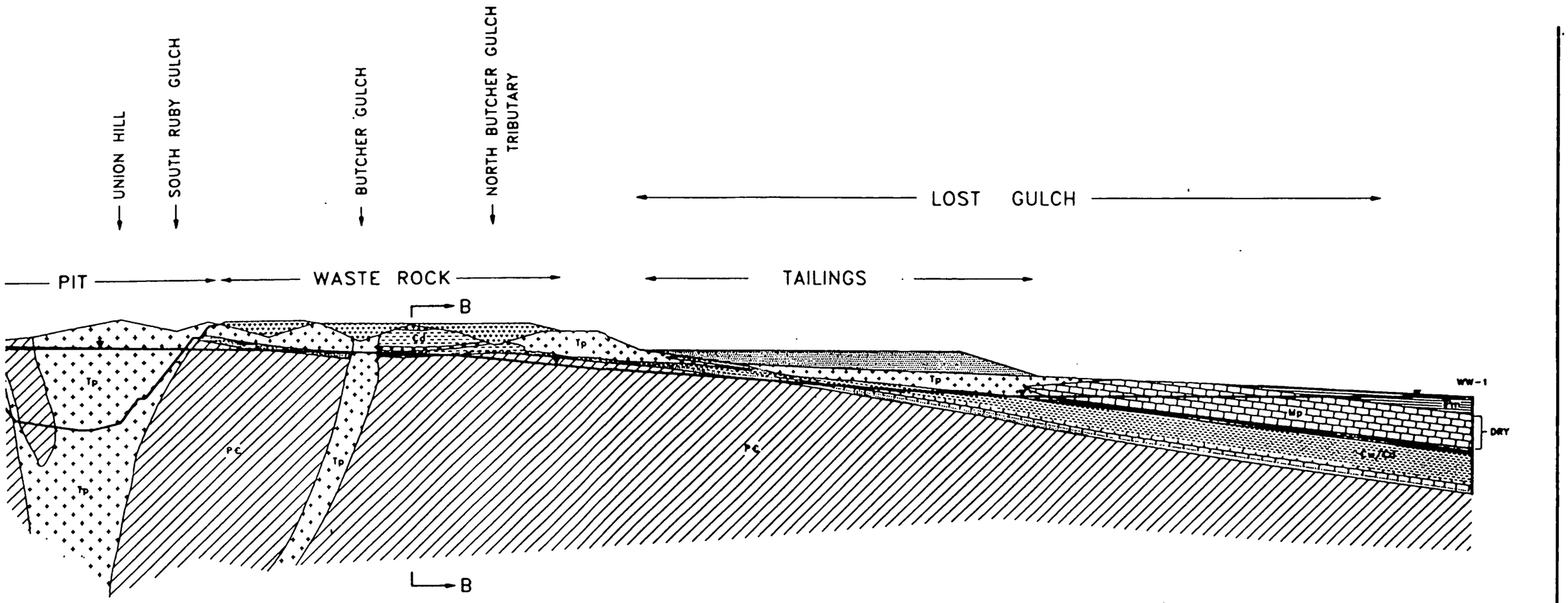
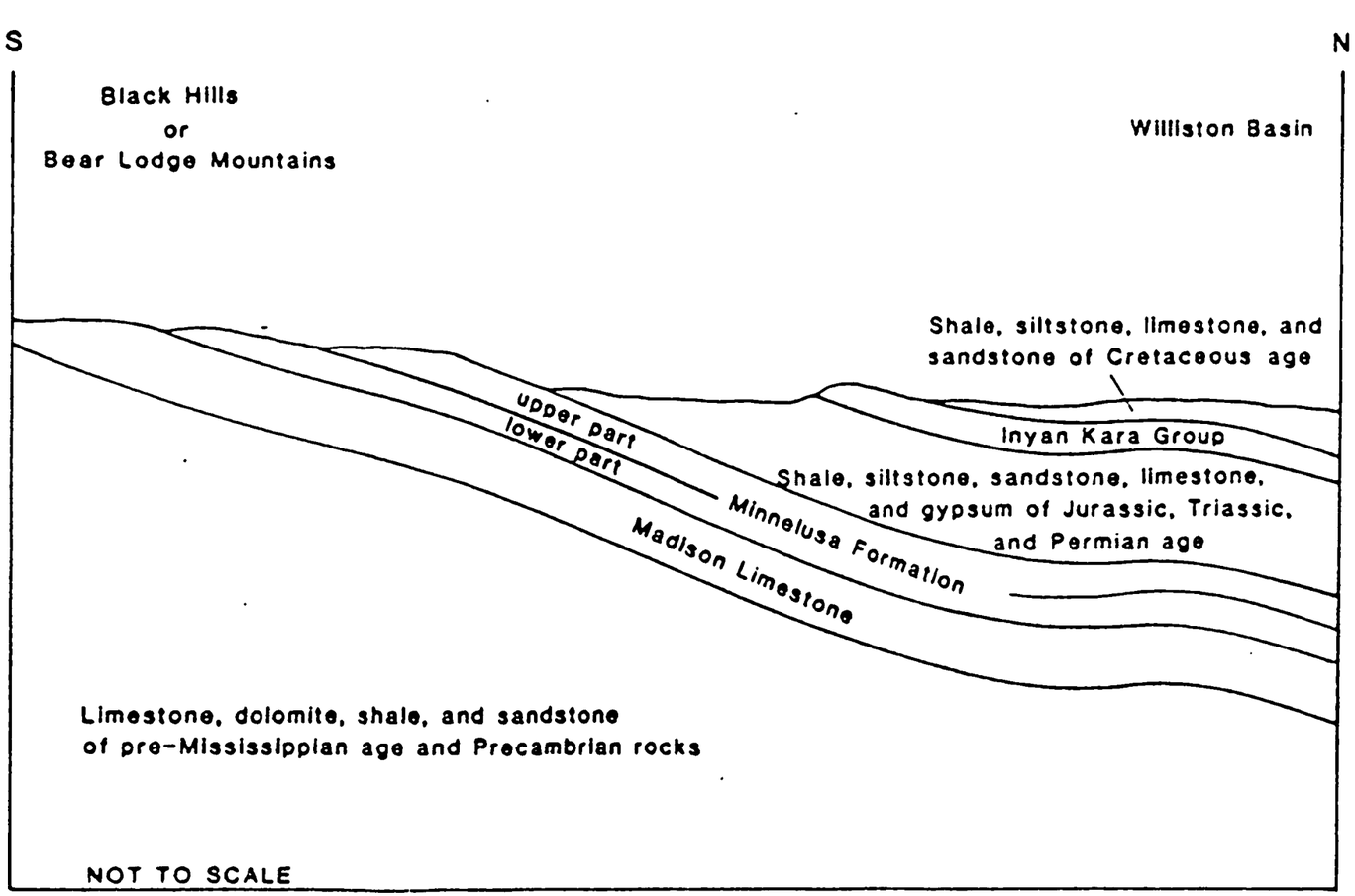
Description	Unit	meq/l #	M17	M17	M18	M19	M20	M21
Date			1976	1976	23-Aug-78	14-Apr-76	30-Jan-62	11-Aug-78
Time			0100	0100		0100	0100	
Station Number	latitude/longitude		444248103442501	444248103442501	444312103465901	444320103471801	445440103465901	445842103454301
ABC Number	(M=Madison)		M17	M17	M18	M19	M20	M21
GENERAL								
X Coordinate	feet		1029214	1029214	1018303	1016984	1022005	1028755
Y Coordinate	feet		343975	343975	346973	347855	416847	441148
Elevation of Land Surface Datum	feet above NGVD		3053	3053	3099	3135	3002	3205
Total Depth of Well	feet		3240	3240	3511	3197		4850
Collecting Agency	code number		1028	1028	1028	1028	46004	1028
Analyzing Agency	code number		1028	1028	80020	1028	46004	80020
FIELD DATA								
pH	su		7.21	7.21	7.1	7.32	7.8	7.5
Alkalinity (field)	mg/l as CaCO3		156	156	153			90
Bicarbonate (field)	mg/l as HCO3	0.01639			190	310		110
Carbonate (field)	mg/l as CO3	0.03333			0			0
Hardness, Total fld Noncarb	mg/l as CaCO3		1000	1000	460	38		1700
Specific Conductance	us/cm		2230	2230	1080	457		2700
GENERAL PARAMETERS								
Water Temperature	degrees C				41.5			23
pH Lab	su							
Alkalinity, Lab	mg/l as CaCO3							
Alkalinity, Methyl Orange	mg/l						150	
Dissolved Carbon Dioxide	mg/l as CO2				23	23	4.7	5.5
Dissolved Organic Carbon	mg/l as C				0.8			1.4
Dissolved Oxygen	mg/l							
Dissolved Residue	mg/l @ 105 deg C				963			3180
Total Suspended Residue	mg/l @ 105 deg C				-1			22
Dissolved Solids	tons/ac-ft				1.18	0.39		3.74
Dissolved Solids Residue	mg/l @ 180 deg C				869			2750
Diss. Solids, Sum of Constituents	mg/l				814	290		2410
Hardness, Total	mg/l as CaCO3		1200	1200	610	290	1400	1700
Sodium Adsorption Ratio			0.5	0.5	0.3	0		0.4
Sodium Percent			7	7	5	1		4
Specific Conductance, Lab	us/cm						299	
MAJOR CATIONS								
Calcium, Dissolved	mg/l as Ca	0.04990	320	320	160	78		510
Magnesium, Dissolved	mg/l as Mg	0.08226	89	89	51	23		110
Sodium, Dissolved	mg/l as Na	0.04350	39	39	14	2		36
Potassium, Dissolved	mg/l as K	0.02557	14	14	5	1		35
Potassium, Total Recoverable	mg/l as K	0.02557						
MAJOR ANIONS								
Bicarbonate, IT-lab	mg-l HCO3	0.01639					188	
Bicarbonate (field)	mg/l as HCO3	0.01639			190	310		110
Carbonate (field)	mg/l as CO3	0.03333			0			0
Chloride, Dissolved	mg/l as Cl	0.02821	41	41	17	3		25
Sulfate, Dissolved	mg/l as SO4	0.02082			450	32	1100	1600
Fluoride, Dissolved	mg/l as F	0.05264			1.7			3.1

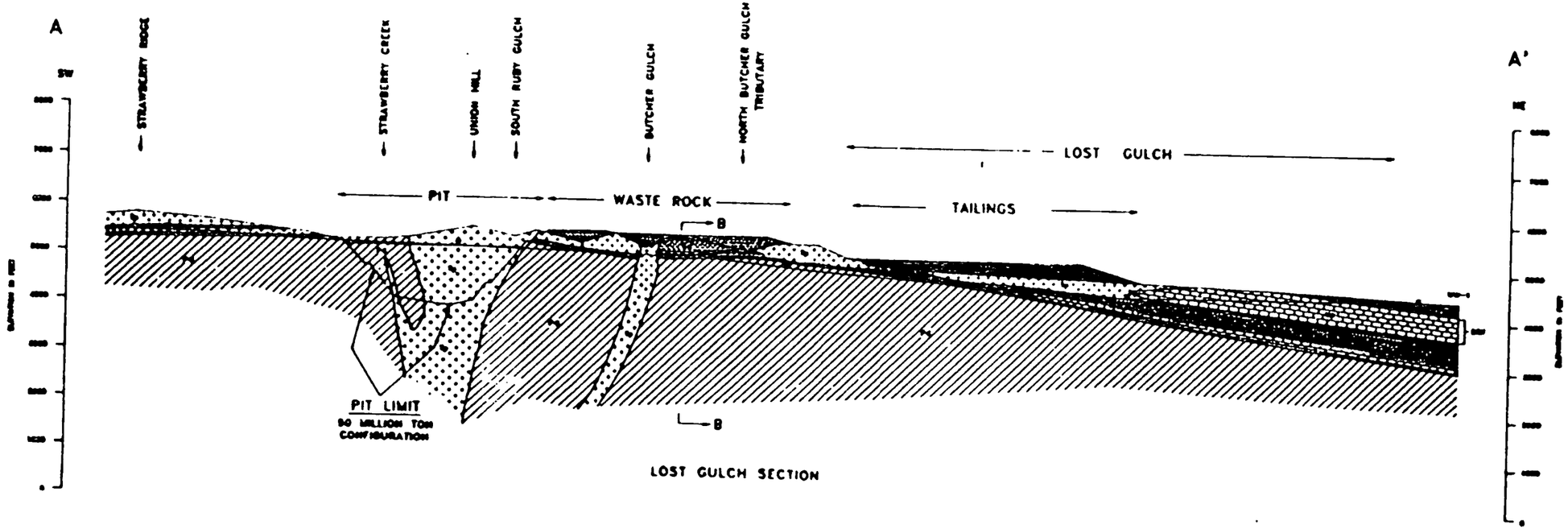
Description	Unit	meq/l #	M17	M17	M18	M19	M20	M21
ION BALANCE								
Total Cations	meq/l		25.34	25.34	12.92	5.90	0.00	36.96
Total Anions	meq/l		1.16	1.16	13.05	5.83	25.98	35.98
Ion Balance	(cations-anions/sum)		91.27%	91.27%	-0.52%	0.55%	-100.00%	1.34%
DISSOLVED SPECIES								
Aluminum, Dissolved	ug/l as Al				-100			-100
Arsenic, Dissolved	ug/l as As				3			2
Barium, Dissolved	ug/l as Ba				-100			-100
Boron, Dissolved	ug/l as B				50			140
Bromide, Dissolved	mg/l as Br				0.4			0.1
Cadmium, Dissolved	ug/l as Cd				ND			ND
Chromium, Dissolved	ug/l as Cr				ND			-20
Copper, Dissolved	ug/l as Cu				2			ND
Iodine, Dissolved	mg/l as I				0.04			0.01
Iron, Dissolved	ug/l Fe				40			7900
Lead, Dissolved	ug/l as Pb				4			ND
Lithium, Dissolved	ug/l as Li				20			90
Manganese, Dissolved	ug/l as Mn				-10			150
Mercury, Dissolved	ug/l as Hg				-0.1			-0.1
Molybdenum, Dissolved	ug/l as Mo				17			34
Nitrogen, Ammonia Dissolved	mg/l as NH4							
Nitrogen, Nitrate Dissolved	mg/l as NO3							
Nitrogen, Nitrate Dissolved	mg/l as N							
Nitrogen, Nitrite Dissolved	mg/l as NO2							
Nitrogen, NO2+NO3 Dissolved	mg/l as N							
Nitrogen Nitrite, Dissolved	mg/l as N							
Phosphorous, Dissolved	mg/l as P				0.01			-0.01
Selenium, Dissolved	ug/l as Se				8			-1
Silica, Dissolved	mg/l as SiO2				20			17
Strontium, Dissolved	ug/l as Sr				3300			12000
Uranium, Natural Dissolved	ug/l as U							
Vanadium, Dissolved	ug/l as V				5			0
Zinc, Dissolved	ug/l as Zn				180			840
TOTAL SPECIES								
Aluminum, Total Recoverable	ug/l as Al							
Arsenic, Total	ug/l as As							
Barium, Total Recoverable	ug/l as Ba							
Boron, Total Recoverable	ug/l as B							
Chromium, Total Recoverable	ug/l as Cr							
Cobalt, Total Recoverable	ug/l as Co							
Copper, Total Recoverable	ug/l as Cu							
Cyanide, Total	mg/l as CN							
Iron, Total Recoverable	ug/l as Fe							
Lithium, Total Recoverable	ug/l as Li							
Manganese, Total Recoverable	ug/l as Mn							
Molybdenum, Total Recoverable	ug/l as Mo							
Nickel, Total Recoverable	ug/l as Ni							
Nitrogen, Ammonia Total	mg/l as NH4							
Nitrogen, Ammonia+Organic Total	mg/l as N				0.05			0.11
Nitrogen, Nitrate Total	mg/l as N							

Ref: 1182/900201

Description	Unit	ueq/l #	M17	M17	M18	M19	M20	M21
Nitrogen, Nitrite Total	ug/l as N							
Nitrogen, NO2+NO3 Total	ug/l as N							
Nitrogen, Total	ug/l as NO3							
Nitrogen, Total	ug/l as N				0.5			0.11
Nitrogen, Total Organic	ug/l as N							
Phosphorous, Total	ug/l as P							
Scandium, Total	ug/l as Sc							
Selenium, Total	ug/l as Se							
Silver, Total Recoverable	ug/l as Ag							
Strontium, Total Recoverable	ug/l as Sr							
Sulfide, Total	ug/l as S				0.2			0.2
Thorium, Total	ug/l as Th							
Titanium, Total	ug/l as Ti							
Uranium, Natural Total	ug/l as U							
Vanadium, Total	ug/l as V							
Zinc, Total Recoverable	ug/l as Zn							
Zirconium, Total	ug/l as Zr							
RADIONUCLIDES								
Cerium 144, Total	pCi/l							
Gross Alpha, Dissolved	pCi/l as U-nat				12			55
Gross Alpha, Dissolved	ug/l as U-nat				18			81
Gross Alpha, Total Suspended	pCi/l as U-nat				-0.3			1.6
Gross Alpha, Total Suspended	ug/l as U-nat				-0.4			2.4
Gross Beta, Dissolved	pCi/l, as Cs-137				8.7			38
Gross Beta, Dissolved	pCi/l as Sr/Yt-90				7.9			34
Gross Beta, Total Suspended	pCi/l as Sr/Yt-90				0.6			0.8
Gross Beta, Total Suspended	pCi/l as Cs-137				0.5			0.8
Radium 226, Dissolved	Radon Method, pCi/l							


UNION HILL
SOUTH RUBY GULCH
BUTCHER GULCH
NORTH BUTCHER GULCH TRIBUTARY
LOST GULCH
PIT
WASTE ROCK
TAILINGS
B
Tp
Cgf
Pc
Mp
WW-1
DRY
B


S
N
Black Hills
or
Bear Lodge Mountains
Williston Basin
Shale, siltstone, limestone, and
sandstone of Cretaceous age
Inyan Kara Group
Shale, siltstone, sandstone, limestone,
and gypsum of Jurassic, Triassic,
and Permian age
upper part
lower part
Minnelusa Formation
Madison Limestone
Limestone, dolomite, shale, and sandstone
of pre-Mississippian age and Precambrian rocks
NOT TO SCALE



LOST GULCH SECTION

LOST GULCH WELL